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VALHALLA SCIENTIFIC, INC.

MODEL 2330A
DIGITAL POWER ANALYZER

OPERATION MANUAL
& Service

VALHALLA SCIENTIFIC

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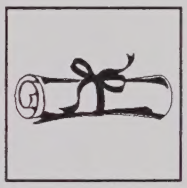
CERTIFICATION

Valhalla Scientific, Inc. certifies that this instrument was thoroughly tested and inspected and found to meet published specifications when shipped from the factory. Valhalla Scientific, Inc. further certifies that its calibration measurements are traceable to the National Institute of Standards and Technology to the extent allowed by NIST's calibration facility.

WARRANTY



The warranty period for this instrument is stated on your invoice and packing list. Please refer to these to determine appropriate warranty dates. We will repair or replace the instrument during the warranty period provided it is returned to Valhalla Scientific, Inc. freight prepaid. No other warranty is expressed or implied. We are not liable for consequential damages. Permission and a return authorization number must be obtained directly from the factory for warranty repairs. No liability will be accepted if returned without such permission. Due to continuing product refinement and due to possible parts manufacturer changes, Valhalla Scientific reserves the right to change any or all specifications without notice.

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SECTION I UNPACKING & INSTALLATION

1-1. Introduction

Valhalla Scientific, Inc. proudly introduces the latest addition to its power measurement line, the Model 2330A Three-Phase Power Analyzer. Based on Valhalla's proven power measurement technology, the 2330A adds a full compliment of the industry's most sought-after features.

The functions of the 2330A are presented on an intelligent multi-channel display that allows simultaneous display of V-A-W for three channels of power. The 2330A is also capable of determining several other items including VA, VAR, PF, Phase angle, frequency, resistance, harmonics, watt-hours and ampere-hours. This is just a partial list of the capabilities of the 2330A. Refer to Section 6 for complete descriptions.

In addition, the IEEE 488.2, RS232C, printer, and analog output ports available on the 2330A make data acquisition possible in most any automated test station.

NOTE: Read this manual thoroughly before attempting to use the power analyzer! Dangerous voltages are routinely present in and connected to this instrument. This instrument may be damaged by improper connections to the rear input terminals. Double check connections before applying power.

We are confident that your Model 2330A will provide years of trouble-free service. If any questions are encountered that cannot be solved by reviewing this manual or if technical support is required, please contact Valhalla Scientific at (800) 548-9806.

1-2. Inspection

If the shipping carton is damaged, request that the carrier's agent be present when the unit is unpacked. If the instrument appears damaged, the carrier's agent should authorize repairs before the unit is returned to the factory. Even if the instrument appears undamaged, it may have suffered internal damage in transit that may not be evident until the unit is operated or tested to verify conformance with its specifications. If the unit fails to operate or fails the tests of Section 2-7, notify the carrier's agent and the nearest Valhalla Sales Office. Retain the shipping carton for the carrier's inspection. DO NOT return equipment to Valhalla Scientific or any of its sales offices prior to obtaining authorization to do so.

1-3. Line Voltage/Fuse Selection

The only adjustments required prior to operation of the 2330A are to set the rear panel selector switch to the local AC line voltage and to verify that the correct fuse for this voltage is fitted. The supply voltages and their corresponding fuses are listed below:

105 to 125 VAC, 50 to 60Hz	1 Amp Slo-Blo
210 to 250 VAC, 50 to 60Hz	0.5 Amp Slo-Blo

ENSURE THAT THE CORRECT LINE VOLTAGE SELECTION IS MADE PRIOR TO APPLYING POWER TO THE 2330A!

1-4. Bench Use

The 2330A is delivered for operation in bench use and special instructions for use in this manner other than the procedures of Sections 4, 5 and 6 are not required.

1-5. Rack Mounting

Optional brackets are available for mounting the 2330A in a standard 19" equipment rack. These are listed in Section 3 of this manual. The size and weight of the 2330A require that the unit be supported on both sides along its entire length by the use of trays or slides. If it is to be transported while mounted in a rack then **it must be supported so as to prevent upward and downward movement.**

The user should note that the specifications for the 2330A become degraded at high temperatures thus it is required that sufficient room be allowed for airflow around the 2330A. This may be achieved by placing a minimum 1.75" blank panel above and below the 2330A in the rack.

If a unit placed beneath the 2330A has an unusually hot exterior top surface and it is not possible to alter its location, it is recommended that an aluminum reflector plate be used between this unit and the 2330A.

Under no circumstances should the ambient air temperature surrounding the 2330A be allowed to exceed 50°C while in operation or 70°C while in storage.

1-6. Safety Precautions

The power connector is a three-contact device and should be mated only with a three-contact connector where the third contact provides a continuous ground connection. A mating power cord has been provided. If the power is provided through an extension cable then the ground connection must be continuous throughout this cable.

Failure to provide a continuous ground connection to the 2330A may render the unit unsafe for use!

SECTION II SPECIFICATIONS

2-1. Voltage Specifications

The accuracy figures given below are valid following a 1 hour warm-up period at the calibration temperature ±5°C. Figures are valid for a period of one year from the date of calibration.

2-1-1. Voltage Ranges and Resolutions

Ranges:	50V	150V	300V	600V
Resolution:	<User-selectable at 4, 5 or 6 digits>			

2-1-2. Voltage Accuracy and Bandwidth

True RMS, DC coupled (AC+DC):

DC:	±0.2% of reading	±0.2% of range
30Hz to 5Khz:	±0.1% of reading	±0.1% of range
5Khz to 15Khz:	±0.5% of reading	±0.25% of range
15Khz to 20Khz:	±0.75% of reading	±0.5% of range

Useable above 20Khz to 100Khz with typically an additional 1% error per 10 Khz.

2-1-3. Miscellaneous Voltage Specifications

Temperature Coefficient: ±10% of accuracy specification per °C

Crest Factor: 50:1 at minimum input linearly decreasing to 2.5:1 at full scale

Minimum Input: 5% of range

Maximum Input: ±1500V peak

Peak Indicator: Illuminates at 2.5 times range, or above the max RMS input for range

Input Impedance: 1MΩ (All Ranges)

2-2. Current Specifications

The accuracy figures given below are valid following a 1 hour warm-up period at the calibration temperature ±5°C. Figures are valid for a period of one year from the date of calibration.

2-2-1. Current Ranges, Resolution and Bandwidth

	Low Shunt	Medium Shunt	High Shunt
Ranges:	0.2A, 0.5A, 1A	2A, 5A, 10A	20A, 50A, 100A
Resolution:	<User-selectable at 4, 5 or 6 digits>		
Impedance:	100mΩ	10mΩ	1mΩ
Bandwidth:	DC & 30Hz-10Khz	DC & 30Hz-5Khz	DC & 30Hz-1Khz
Max Input:	2A continuous	20A continuous	150A continuous
Peak Input: (no damage)	100msec @5A (fused)	100msec @50A	100msec @500A

2-2-2. Current Accuracy

True RMS, DC coupled (AC+DC):

DC:	±0.5% of reading	±0.5% of range
30Hz to Bandwidth: (Shunt Dependant)	±0.25% of reading	±0.25% of range

2-2-3. Miscellaneous Current Specifications

Temperature Coefficient: ±10% of accuracy specification per °C

Crest Factor: 50:1 at minimum input linearly decreasing to 2.5:1 at full scale

Minimum Input: 5% of range

Peak Indicator: Illuminates at 2.5 times range, or above maximum RMS input for range

Shunt Compliance Voltage: 100mV at full scale on highest range for shunt (1A, 10A, 100A)

2-3. Power Specifications

The accuracy figures given below are valid following a 1 hour warm-up period at the calibration temperature ±5°C. Figures are valid for a period of one year from the date of calibration.

2-3-1. Power Accuracy and Bandwidth

True RMS, DC coupled (AC+DC):

DC:	±0.5% of volts x amps readings	±0.5% of volts x amps ranges
30Hz to Bandwidth: (Shunt Dependant)	±0.25% of volts x amps readings	±0.25% of volts x amps ranges

Bandwidth: DC and 30Hz to 10Khz (low shunt)
DC and 30Hz to 5Khz (medium shunt)
DC and 30Hz to 1Khz (high shunt)

Temperature Coefficient: ±10% of accuracy specification per °C

Power Factor Response: 0.01 to unity (1.000) power factor, leading or lagging

Power Factor Accuracy: ±0.005PF from 30Hz to 1000Hz
±0.010PF from 1Khz to 5Khz
±0.050PF from 5Khz to 10Khz

Phase Accuracy: Phase shift is a calculated value based on the V-A-W readings. Accuracy is equal to the combined uncertainties for voltage, current, and power. Typical phase accuracy is ±1° to 5Khz.

2-4. Physical Specifications

Height: 7" (178mm) not including feet
Width: 17" (432mm)
Depth: 19.75" (490mm)
Weight: 26 lbs (12kg) net; 31 lbs (14.5kg) shipping

2-5. Environmental Specifications

Temperature Range: Operating: 0°C to 50°C
Storage: -20°C to +75°C

Humidity: 70% RH max @ 40°C (non-condensing)

Power: 50 to 60Hz @ 105-125VAC or 210-250VAC; 60VA max

2-6. Miscellaneous Specifications

Settling Time: (to within 0.05% of change)
No range change: 1.5 sec
Following range change: 5 sec

Maximum Common Mode Voltage: 1500V peak from any terminal to chassis

Input Configuration: Three-wire type wattmeter with three current inputs for each phase

Display Type: Vacuum-fluorescent, 4 rows, 42 characters per row

A-to-D Converter Resolution: 20 bit (1 million counts)
A-to-D Converter Conversion Rate: 212ms

Frequency counter response: 0.2Hz to 52kHz
Frequency counter accuracy: > 1Hz = ±0.01% of frequency ±250ns
< 1Hz = ±0.1% of frequency ±16.8ms

2-7. Performance Verification

Performance of the Model 2330A may be verified at any time, and is recommended following receipt of the unit or following transportation. Verification may be achieved with two levels: verified as operational; verified as operational and within specifications. The procedures for both follow.

2-7-1. Verification of Operation

If the 2330A fails any of the tests that follow, employ normal troubleshooting procedures or consult the factory for advice.

1) Ensure that the POWER switch (lower left hand corner of the front panel) of the 2330A is in the OFF position.
2) Ensure that the rear panel switch is set to the correct local line voltage and apply AC power to the 2330A. Make no connections to the shunt input terminals under the flip-lid.
3) Press the 2330A POWER switch to the ON position. The 2330A should come to life and introduce itself to the user.
4) Allow the 2330A to warm up for 15 minutes.

5) Connect the 2330A as described in Section 6-4-1 to a known resistive load, e.g. a 100-watt incandescent light bulb. Verify that the voltage display reads the present line voltage, the current display reads approximately 1 amp, and the power display reads approximately 100 watts. This should be repeated for each of the 3 channels: ϕA, ϕB and ϕC.

After successful completion of all of the steps above, the 2330A is fully operational with no faulty parts apparent.

2-7-1. Verification of Specification

Attempting to prove that the 2330A is performing to specification requires that the user be aware of the following points:

1) The specifications in Section 2 are valid for reasonable use of the 2330A during the specified period of time. If the 2330A has been transported it may have been subjected to extremes of temperature. As with any precision equipment some change in calibration may occur due to this. This effect has been carefully monitored by Valhalla Scientific and has been found to be small, even in extreme cases.
2) A wattmeter calibration system is required to verify the specifications of the 2330A. A source of voltage and current in phase with each other is required to check the power accuracy. Phase shifts between voltage and current will cause measurement errors. The calibration procedure of Section 8 may be used as a guide for verifying specifications.
3) Prior to specification verification it is recommended that the user be familiar with the manual operation of the 2330A and allow at least one hour for the unit to warm up.

If the 2330A is found to be fully operational but not performing to specifications it is recommended that a full calibration be performed. If this does not bring all points within specifications, contact your nearest Valhalla Scientific Service Center before returning the unit for repair or attempting to repair the unit yourself.

SECTION III AVAILABLE OPTIONS

3-1. General

The following options are available for the 2330A Digital Power Analyzer.

3-2. Expanded Current Range

The standard 100-ampere current measurement capability of the 2330A may be extended through the use of Valhalla Options I-150, I-1000 or Valhalla Model 1000A described below.

3-2-1. Options I-150 and I-1000

These options are 150-amp and 1000-amp clamp-on type current transformers, respectively. Both have 1000:1 ratios with approximately 1% accuracies from 50Hz to 400Hz. Option I-150 accommodates up to 0.5" diameter conductors. Option I-1000 accommodates up to 2" diameter conductors.

3-2-2. Valhalla Model 1000A

The newest addition to the list of options for the Model 2330A Power Analyzer is the Valhalla Model 1000A Precision High Current Measurement System. This unique instrument has the ability to directly measure up to 1000 amps (AC+DC) at a basic accuracy of ±0.02% for DC. The modular design of the 1000A allows expandable current capacity in increments of 300 amps, 500 amps, 700 amps and 1000 amps. The 1000A may be matched to a Model 2330A to provide watts measurement capability. Please contact your local Valhalla representative or the factory for more details.

3-3. Analog Outputs

Option "IOX" provides 11 simultaneous chassis-ground referenced analog outputs corresponding to ϕA volts, amps, watts; ϕB volts, amps, watts; ϕC volts, amps, watts; 3ϕ 3-wire total watts and 3ϕ 4-wire total watts.

3-3-1. Scaling and Accuracy

The scale factors and accuracies of the analog outputs are listed below:

Full Scale Voltage and Accuracy (1 year, 1 hour warm-up)

Watts:	5.0V	±0.5% of output ± 15mV
Volts:	5.0V	±0.5% of output ± 15mV
Amps:	5.0V	±0.5% of output ± 15mV
3ϕ:	7.5V	±1.5% of output ±45mV

3-3-2. Calibration

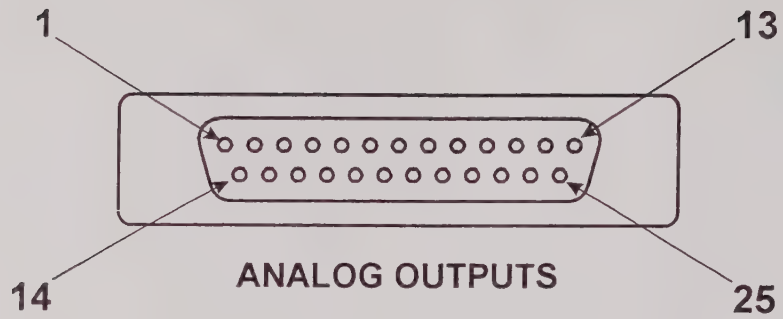
Refer to Section 8 of this manual for the Option IOX calibration procedure.

3-3-3. Connections

Connections to the analog outputs are made via a rear panel connector. A mating connector is supplied with the Option IOX. Additional connectors are available from Valhalla Scientific under stock #05-10357. Connector pin assignments are shown in Figure 3-1.

3-3-4. Drive Capability

A maximum of ±5mA may be drawn from each output without exceeding the accuracy specifications.



PIN	FUNCTION
1	ØA VOLTS
2	ØA AMPS
3	ØA WATTS
4	ØB VOLTS
5	ØB AMPS
6	ØB WATTS
7	ØC VOLTS
8	ØC AMPS
9	ØC WATTS
10	3Ø 3 - WIRE TOTAL WATTS
11	3Ø 4 - WIRE TOTAL WATTS
14 - 24	COMMON
12,13,25	NOT USED

Figure 3-1. Option IOX Connections (2330A)

3-4. Rack-Mount Adapter

Option "R7" is a set of rack ears that allow mounting of the 2330A in a standard 19" equipment rack.

3-5. IEEE Interface

Option "IEEE" provides the 2330A with a full talk/listen IEEE-488.2 digital interface. This interface may be used for remote range programming and for remote data acquisition. See Section 7 for details.

3-6. RS232C Interface

Option "RS232" provides the 2330A with a full talk/listen serial digital interface. This interface may be used for remote range programming and for remote data acquisition. See Section 7 for details.

3-7. Printer Interface

Option "PAR" is a talk-only Centronics parallel printer interface. This port may be used to drive many different types of IBM compatible printers that use this common interface.

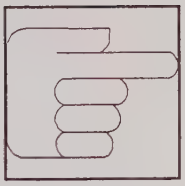
3-8. GPIB Cables

GPIB IEEE-488.2 interface cables are available from Valhalla Scientific in lengths of 1 or 2 meters. These items are designated as Option "GP-1" or "GP-2", respectively.

3-9. Harmonic Analysis

Option "HARM" provides the 2330A with the ability to measure harmonic frequencies which may be riding on the fundamental frequency of a waveform.

SECTION IV FRONT PANEL CONTROLS



4-1. General

This section outlines the use of each of the front panel controls and connectors. The user is advised to also read Sections 5, 6 and 7 to obtain full descriptions of the methods of operation of the 2330A.

The paragraph numbers used in this section correspond to the reference numbers of Figure 4-1.

4-1-1. Multi-Channel Display Window

This window is used to display measured values, calculations, calibration data, error messages, and user prompts. The display is fully configurable for maximum utility.

The display shown is typical of a 3-channel unit. Single-channel units show nearly all available fields for channel A. Refer to section 6-5 for descriptions of the fields by name.

4-1-2. LED Indicators

This bank of indicators is used to alert the user to conditions that may affect measurements or operation of the 2330A.

4-1-3. POWER Switch

This two-position switch is used to apply or remove power from the internal circuits of the 2330A.

4-1-4. FUNCTION Keys

These keys are used to select a desired function of the 2330A for presentation on the display.

4-1-5. DATA ENTRY Keys

These keys are used to provide the 2330A with numeric information that is used in functions such as CT ratios, filters, harmonics, etc. Data entry keys (1-4) may be used to replace the cursor keys in selecting menu choices. i.e. To select the first item from the left, press 1. To select the second item from the left, press 2, and so on.

4-1-6. MODE Keys

The keys in the MODE section are used to set up the display, range, and system configurations.

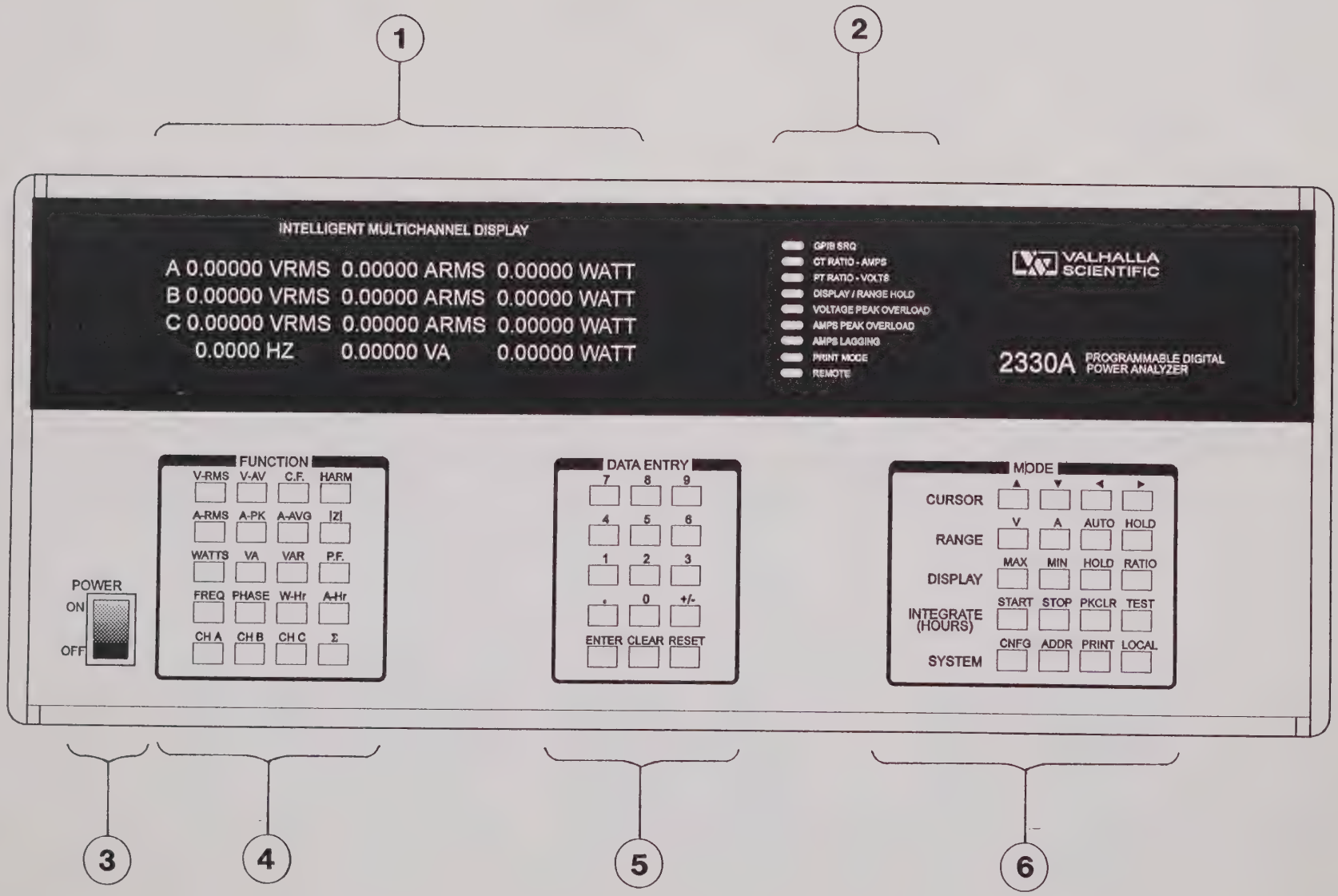
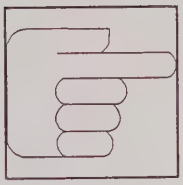


Figure 4-1. 2330A Front Panel

SECTION V REAR PANEL CONNECTIONS



5-1. General

This section outlines the functions of the rear panel controls and connectors. The user is advised to also refer to Sections 4, 6 and 7 for complete operating instructions. The paragraph numbers used in this section correspond to the reference numbers of Figures 5-1 and 5-2.

5-1-1. Power Connector

This is the instrument AC power connector. Use an approved 3-prong cord *only*.

5-1-2. Fuseholder

This contains the main AC power fuse. Fuse values for the different operating voltages are listed on the 2330A rear panel. **Caution!** Never attempt to change a fuse with the power cord connected.

5-1-3. Line Voltage Switch

This switch selects the instrument AC power voltage between 115VAC or 230VAC.

5-1-4. GPIB INTERFACE Connector

This connector, if installed, is the general purpose interface bus (GPIB) connector.

5-1-5. PRINTER INTERFACE Connector

This connector, if installed, is the port that may be connected to a Centronics compatible parallel printer.

5-1-6. RS232 INTERFACE Connector

This connector, if installed, is the RS232C port for remote serial operations.

5-1-7. "ϕA Terminal Cluster"

These are the input terminals for channel A (⌀A).

5-1-8. "ϕB Terminal Cluster"

These are the input terminals for channel B (⌀B). These terminals are not installed in single- or dual-channel versions.

5-1-9. "ϕC Terminal Cluster"

These are the input terminals for channel C (⌀C). These terminals are not installed in single-channel versions.

☞ For protection purposes, the 2330A has a fuse installed in-line with the Low Shunts (Ranges .2, .5, 1). This is a 5 Amp Fast-blo fuse. If problems are observed when using the Low Shunt, ensure that these fuses are not blown. Replace blown fuses with the exact replacement part only!

5-1-10. ANALOG OUTPUT Connector

This connector, if installed, provides analog outputs proportional to the V-A-W data measured by the 2330A. This optional feature is called Option "IOX". Refer to Figure 3-1 for pin functions, section 3-3-1 for accuracies, and section 8-5 for calibration adjustments.

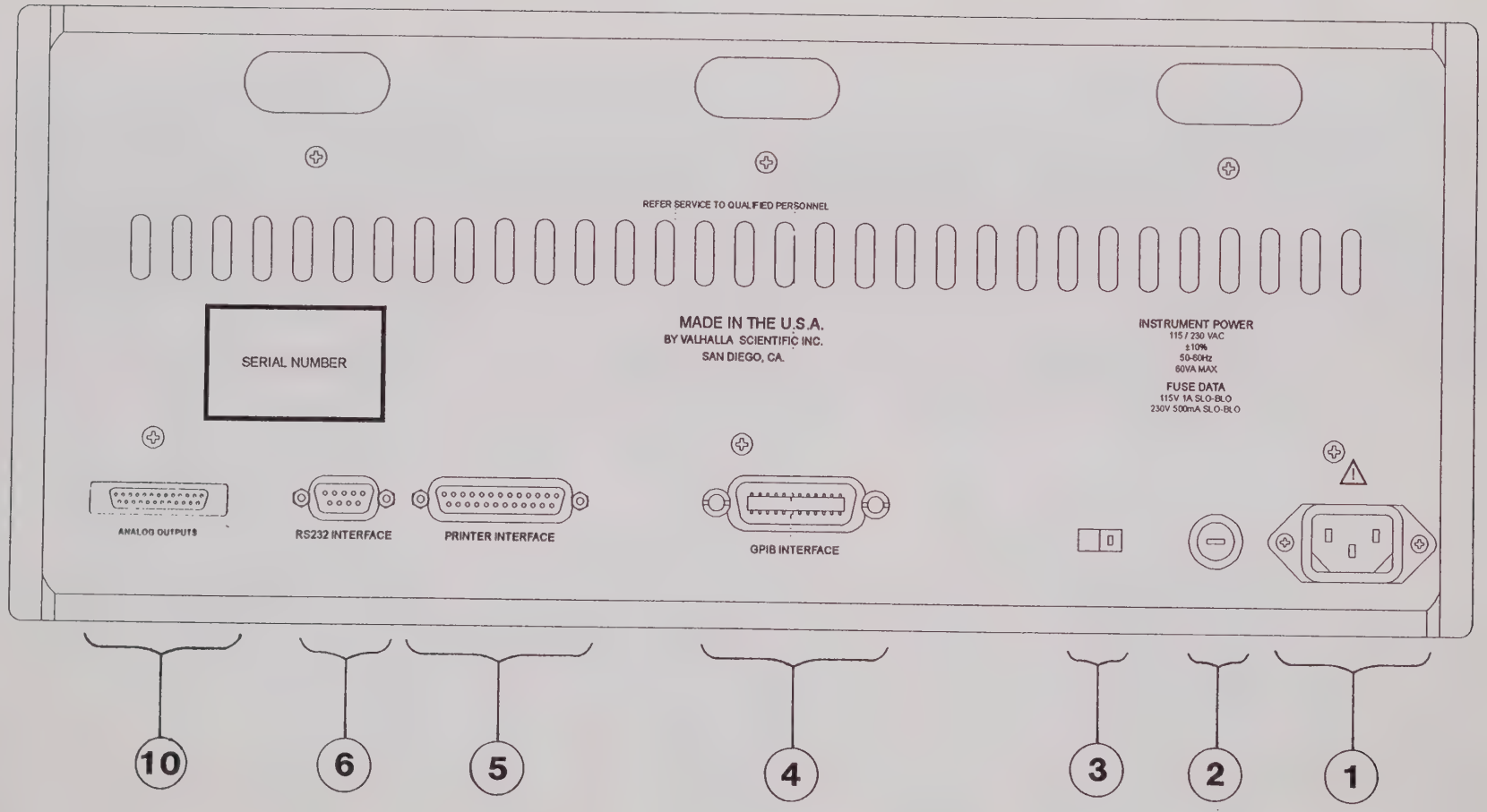


Figure 5-1. 2330A Rear Panel

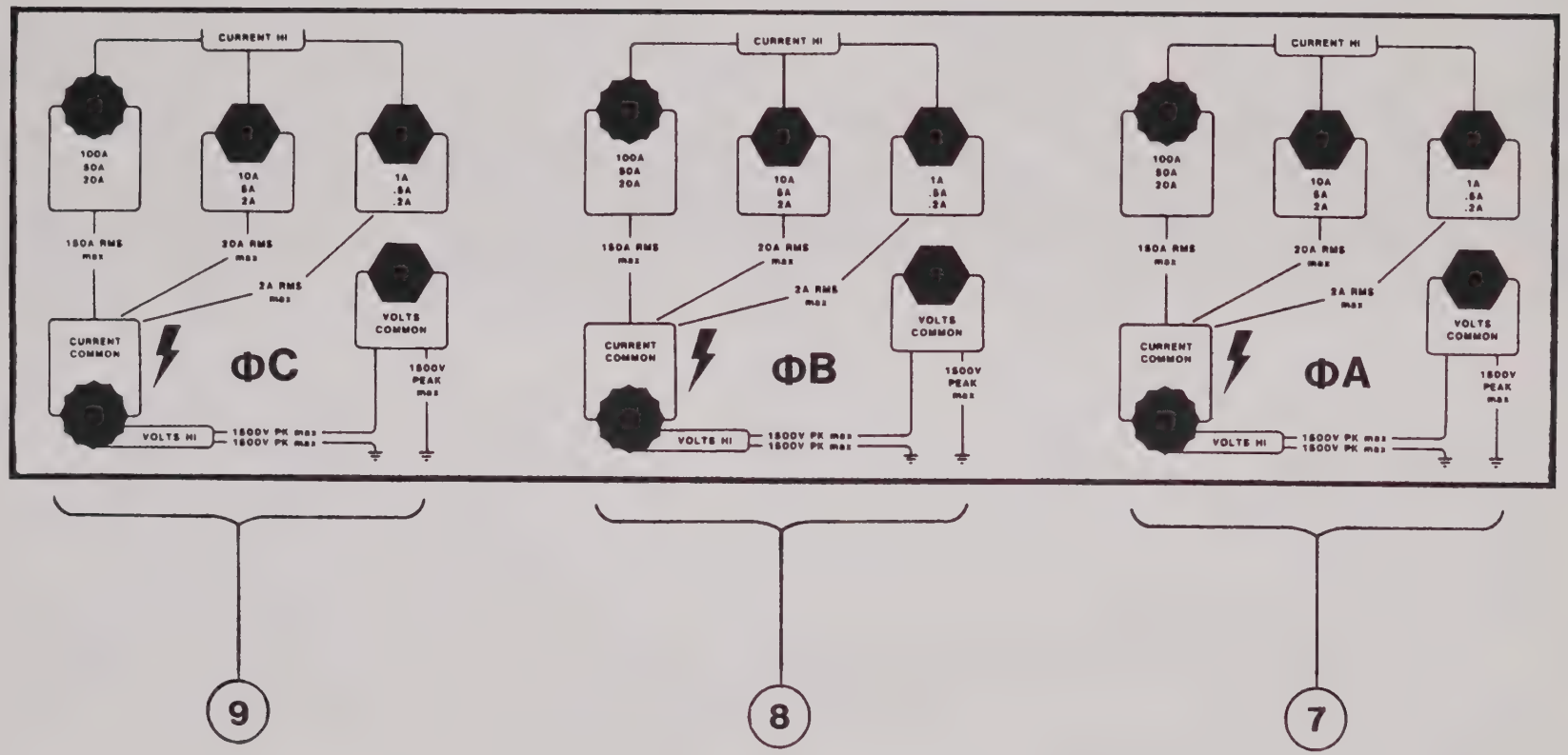
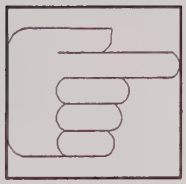


Figure 5-2. 2330A Shunt Terminals



6-1. General

The following paragraphs describe the manual operation of the 2330A Power Analyzer and should be used along with Sections 4 and 5 for complete operating instructions. The user is advised to fully read these sections before attempting to operate the 2330A. Section 7 describes 2330A operation via the various interfaces available.

The 2330A has been designed to provide maximum versatility with minimum effort. The display may be operated in the full-feature mode (default), or it may be trimmed to fit the needs of a particular user or application.

In many cases, the same functions are accessible through discrete keys or through the cursor-controlled menu system of the 2330A. Don't be afraid to experiment until the best method of achieving the desired result is found. The 2330A cannot be damaged by an incorrect key-press, and any situation is reversible! (usually by pressing CLEAR) In any case, if a desired result cannot be accomplished, full technical support is available by calling Valhalla Scientific at 1 800 548-9806, or your local sales representative.

6-2. Safety Precautions

CAUTION!!

IN NORMAL USE THE TERMINALS OF THE 2330A ARE CONNECTED TO LETHAL VOLTAGES. DEATH MAY OCCUR ON CONTACT!

Do not attach or remove wires without first checking that all power sources have been disabled. Do not open-circuit the secondary windings of current transformers when they are energized. Lethal potentials may exist which can damage the transformer, the 2330A, and the operator.

6-3. Power Measurement Theory

The 2330A contains three independent wattmeter channels (a.k.a. "phases" or "ϕ"). Single-phase power may be measured using any of the three channels. Three simultaneous, isolated, single-phase measurements may also be made.

When measuring three-phase power, the number of leads connected to the load determines how the 2330A is connected. If the load has three-wires, the two-wattmeter method is used to measure the total power. The total power is the sum of the two wattmeter readings. Phase B is used as the reference (neutral) for the other channels. Wattmeter channel A measures the current in phase A and the voltage between phase A and phase B. Channel C measures the current in phase C and the voltage between phase C and phase B. Phase B is not used other than as a reference. The 2330A sums the phase A and C power readings to determine total power. A complete proof of the validity of the two wattmeter method is beyond the scope of this manual, and may be found in a college level electrical engineering textbook.

If the load has four-wires, all three wattmeters must be used to measure the total power. The total power is the sum of the three wattmeter readings. Channel A measures the current in phase A and the voltage between phase A and neutral. Channels B and C similarly measure phases B and C. The 2330A sums the

phase A, B, and C readings to determine total power.

6-4. Connections

The 2330A has a separate cluster of terminals for each of the three channels. Each channel has three current terminals, with use determined by the amount of current to be measured. The three current terminals are internally connected to the 1 ampere, 10 ampere, or 100 ampere shunts. The opposite ends of the three shunts are connected together to the CURRENT COMMON - VOLTS HIGH terminal. The 2330A measures the voltage between the CURRENT COMMON - VOLTS HIGH terminal and the VOLTS COMMON terminal on all voltage ranges. Connections to the 2330A vary widely depending on the application. Most conceivable configurations are described in the following paragraphs. If your particular application is not represented, also refer to the Application Notes of Section 11.

The paragraph numbers correspond to the Figure numbers at the end of this section. The single-phase connections are shown using channel C of the 2330A, however any of the channels (A, B, or C) may be used for single-phase measurements.

6-4-1. Single-Phase Two-Wire Load Power Connections

Connect the wattmeter as shown in Figure 6-1. **Caution!** Do not run the neutral current through the VOLTS COMMON terminal. Tap off the neutral wire to connect the VOLTS COMMON terminal.

6-4-2. Single-Phase Two-Wire CT Load Power Connections

Connect the wattmeter as shown in Figure 6-2. Observe the polarities of the current transformer. The watts and current readings should be multiplied by the CT ratio, or utilize the "CT RATIO" function to automatically adjust measurements. **Caution!** Do not run the load current through the VOLTS COMMON terminal. Tap off the neutral wire to connect the VOLTS COMMON terminal.

6-4-3. Single-Phase Two-Wire PT Load Power Connections

Connect the wattmeter as shown in Figure 6-3. Observe the polarity of the potential transformer. The watts and voltage readings should be multiplied by the PT ratio, or utilize the "PT RATIO" function to automatically adjust measurements. **Caution!** Do not exceed the common-mode rating of the Model 2330A.

6-4-4. Single-Phase Two-Wire CT-PT Load Power Connections

Connect the wattmeter as shown as Figure 6-4. Observe the polarities of the current and potential transformers. The watts reading should be multiplied by the PT and CT ratios, or utilize the "CT and PT RATIO" functions to automatically adjust measurements. The CURRENT COMMON terminal should be grounded for best performance.

6-4-5. Single-Phase Two-Wire Source Power Connections

Some applications require measuring the power from a source rather than the power into the load. These connections are shown in Figure 6-5. When the model 2330A is connected in this manner, the watts reading should be multiplied by minus one (-1). **Caution!** Do not run the neutral current through the VOLTS COMMON terminal. Tap off the neutral wire to connect the VOLTS COMMON terminal.

6-4-6. Single-Phase Two-Wire CT Source Power Connections

Some applications require measuring the power from a source rather than the power into the load. These connections are shown in Figure 6-6. When the Model 2330A is connected in this manner, the watts reading should be multiplied by minus one (-1) and the CT ratio, or use the "CT RATIO" function to adjust displayed measurements automatically. Observe the polarity of the current transformer. **Caution!** Do not run the neutral current through the VOLTS COMMON terminal. Tap off the neutral wire to connect the VOLTS COMMON terminal.

6-4-7. Single-Phase Two-Wire PT Source Power Connections

Some applications require measuring the power from the source rather than the power into the load. These connections are shown in Figure 6-7. When the Model 2330A is connected in this manner, the watts reading should be multiplied by minus one (-1) and the PT ratio, or use the "PT RATIO" function to adjust displayed measurements automatically. Observe the polarity of the potential transformer. **Caution!** Do not exceed the common-mode specification of the Model 2330A.

6-4-8. Single-Phase Two-Wire CT-PT Source Power Connections

Some applications require measuring the power from a source rather than the power into the load. These connections are shown in Figure 6-8. When the Model 2330A is connected in this manner, the watts reading should be multiplied by minus one (-1) and the CT-PT ratios, or use the "CT and PT RATIO" functions to adjust displayed measurements automatically. Observe the polarities of the current and potential transformers. For best performance the CURRENT COMMON terminal should be grounded.

6-4-9. Three-Phase Three-Wire Load Power Connections

Connect the wattmeter as shown in Figure 6-9. **Caution!** Do not run phase B current through the VOLTS COMMON terminals. Tap off the phase B wire to connect the VOLTS COMMON terminals.

6-4-10. Three-Phase Three-Wire CT Load Power Connections

Connect the wattmeter as shown in Figure 6-10. Observe the polarities of the current transformers. The watts and current readings should be multiplied by the CT ratio, or use the "CT RATIO" function to adjust displayed measurements automatically. **Caution!** Do not run the line current through the CURRENT or VOLTS COMMON terminals.

6-4-11. Three-Phase Three-Wire PT Load Power Connections

Connect the wattmeter as shown in Figure 6-11. Observe the polarities of the potential transformers. The watts and voltage readings should be multiplied by the PT ratio, or use the "PT RATIO" function to adjust displayed measurements automatically. **Caution!** Do not exceed the common-mode specifications of the Model 2330A.

6-4-12. Three-Phase Three-Wire CT-PT Load Power Connections

Connect the wattmeter as shown in Figure 6-12. Observe the polarities of the current and potential transformers. The watts reading should be multiplied by the CT-PT ratios, or use the "CT and PT RATIO" functions to adjust displayed measurements automatically. For best performance ground the CURRENT COMMON terminals.

6-4-13. Three-Phase Three-Wire Source Power Connections

Some applications require measuring the power from a source rather than the power into the load. These connections are shown in Figure 6-13. When the Model 2330A is connected in this manner, the watts reading should be multiplied by minus one (-1). **Caution!** Do not run the phase B current through the VOLTS COMMON terminals. Tap off the phase B wire to connect the VOLTS COMMON terminals.

6-4-14. Three-Phase Three-Wire CT Source Power Connections

Some applications require measuring the power from a source rather than the power into the load. These connections are shown in Figure 6-14. When the model 2330A is connected in this manner, the watts reading should be multiplied by minus one (-1) and the CT ratio, or use the "CT RATIO" function to adjust measurements automatically. Observe the polarity of the current transformer. **Caution!** Do not run the line current through the CURRENT or VOLTS COMMON terminal. Tap off the line wires to connect the CURRENT and VOLTS COMMON terminals.

6-4-15. Three-Phase Three-Wire PT Source Power Connections

Some applications require measuring the power from a source rather than the power into a load. These connections are shown in Figure 6-15. When the Model 2330A is connected in this manner, the watts reading should be multiplied by minus one (-1) and the PT ratio, or use the "PT RATIO" function to adjust displayed measurements automatically. Observe the polarities of the potential transformers. **Caution!** Do not exceed the common-mode specifications of the Model 2330A.

6-4-16. Three-Phase Three-Wire CT-PT Source Power Connections

Some applications require measuring the power from a source rather than the power into a load. These connections are shown in Figure 6-16. When the Model 2330A is connected in this manner, the watts reading should be multiplied by minus one (-1) and the CT-PT ratios, or use the "CT and PT RATIO" functions to adjust displayed measurements automatically. Observe the polarities of the current and potential transformers. For best performance, the CURRENT COMMON terminals should be grounded.

6-4-17. Three-Phase Four-Wire Load Power Connections

Connect the wattmeter as shown in Figure 6-17. **Caution!** Do not run the neutral current through the VOLTS COMMON terminals. Tap off the neutral wire to connect the VOLTS COMMON terminals.

6-4-18. Three-Phase Four-Wire CT Load Power Connections

Connect the wattmeter as shown in Figure 6-18. Observe the polarities of the current transformers. The watts and current readings should be multiplied by the CT ratio, or use the "CT RATIO" function to adjust displayed measurements automatically. **Caution!** Do not run the line or neutral currents through the current or volts COMMON terminals.

6-4-19. Three-Phase Four-Wire PT Load Power Connections

Connect the 2330A as shown in Figure 6-19. Observe the polarities of the potential transformers. The watts and voltage readings should be multiplied by PT ratio, or use the "PT RATIO" function to adjust measurements automatically. Do not exceed the common mode specifications of the 2330A.

6-4-20. Three-phase Four-Wire CT-PT Load Power Connections

Connect the wattmeter as shown in Figure 6-20. Observe the polarities of the current and potential transformers. The watts reading should be multiplied by CT-PT ratios, or use the "CT and PT RATIO" functions to adjust displayed measurements automatically. For best performance, ground the CURRENT COMMON terminals.

6-4-21. Three-phase Four-Wire Source Power Connections

Some applications require measuring the power from a source rather than the power into a load. These connections are shown in Figure 6-21. When the Model 2330A is used in this manner, the watts reading should be multiplied by minus one (-1). **Caution!** Do not run the neutral current through the VOLTS COMMON terminals. Tap off the neutral wire to connect to the VOLTS COMMON terminals.

6-4-22. Three-phase Four-Wire CT Source Power Connections

Some applications require measuring the power from a source rather than the power into a load. These connections are shown in Figure 6-22. When the Model 2330A is used in this manner, the watts reading should be multiplied by minus one (-1) and the CT ratio, or use the "CT RATIO" function to adjust displayed measurements automatically. Observe the polarities of the current transformers. **Caution!** Do not run the line or neutral currents through the VOLTS COMMON terminals. Tap off the line and neutral wires to connect the VOLTS COMMON terminals.

6-4-23. Three-phase Four-Wire PT Source Power Connections

Some applications require measuring the power from a source rather than the power into a load. These connections are shown in Figure 6-23. When the Model 2330A is used in this manner, the watts reading should be multiplied by minus one (-1) and the PT ratio, or use the "PT RATIO" function to adjust displayed measurements automatically. Observe the polarities of the potential transformers. **Caution!** Do not exceed the common mode specifications of the Model 2330A.

6-4-24. Three-phase, Four-Wire CT-PT Source Power Connections

Some applications require measuring the power from a source rather than the power into a load. These connections are shown in Figure 6-24. When the Model 2330A is used in this manner, the watts reading should be multiplied by minus one (-1) and the CT-PT ratios, or use the "CT and PT RATIO" functions to adjust displayed measurements automatically. Observe the polarity of the current and potential transformers. For best performance the CURRENT COMMON terminals should be grounded.

6-5. Understanding the 2330A Display

The display of the 2330A has been designed to the provide the greatest amount of data in a format that is organized and versatile. The power-up (default) display configuration for a 3-channel unit is shown in Figure 4-1.

It is helpful to note that the display is divided into 4 rows, each with its own corresponding data. In 3-channel units, the top 3 "channel" rows contain data for the three channels of power: ϕA, ϕB, and ϕC. The fourth or "summing" row is for functions such as total power, frequency, user messages

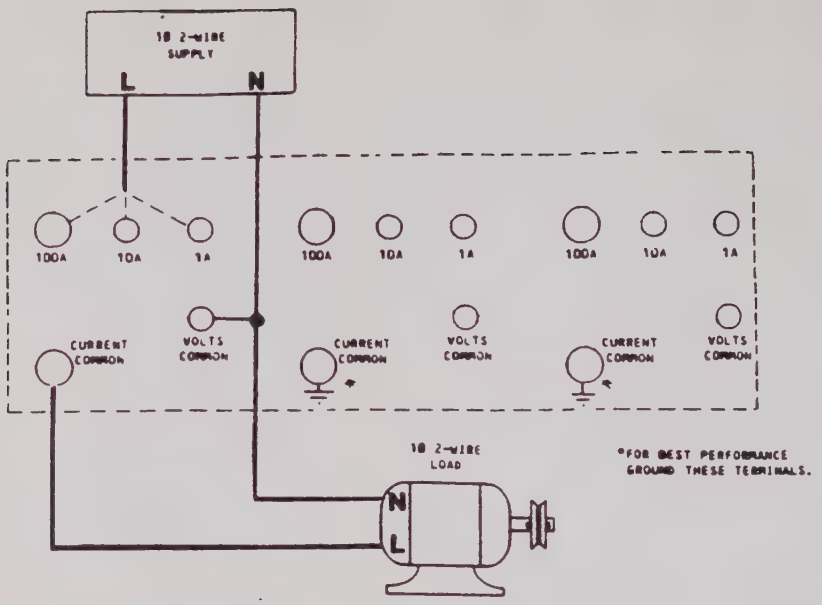


Figure 6-1 Single-PHASE Two-Wire Load Power Connections

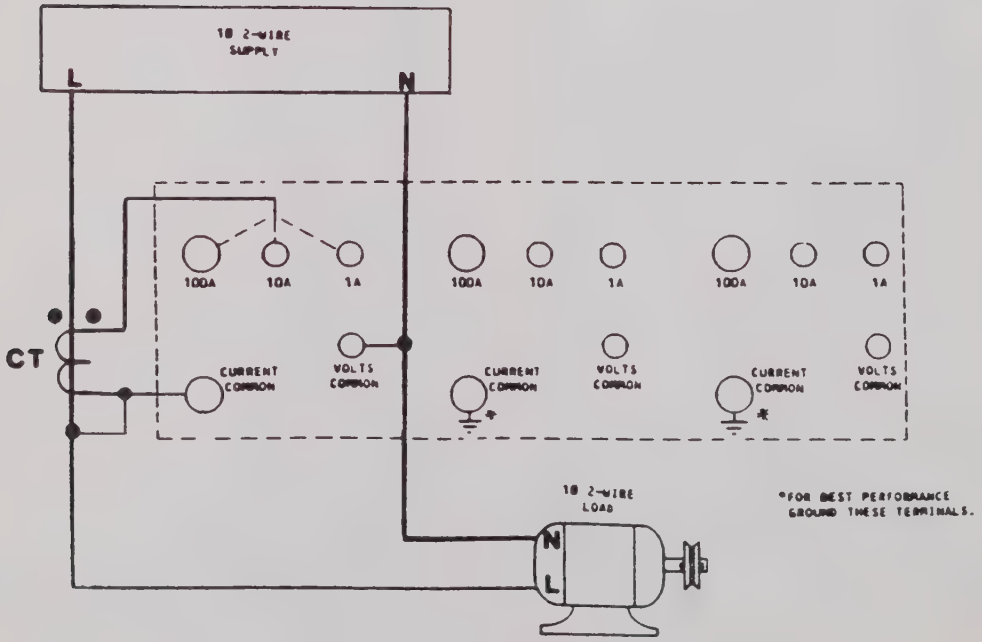


Figure 6-2 Single-Phase Two-Wire CT Load Power Connections

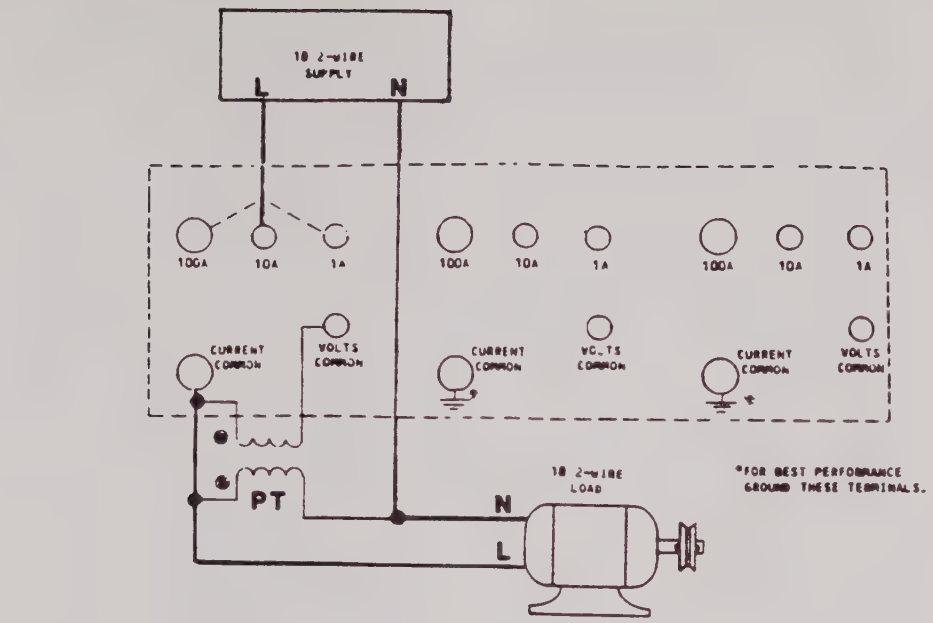


Figure 6-3 Single-Phase Two-Wire PT Load Power Connections

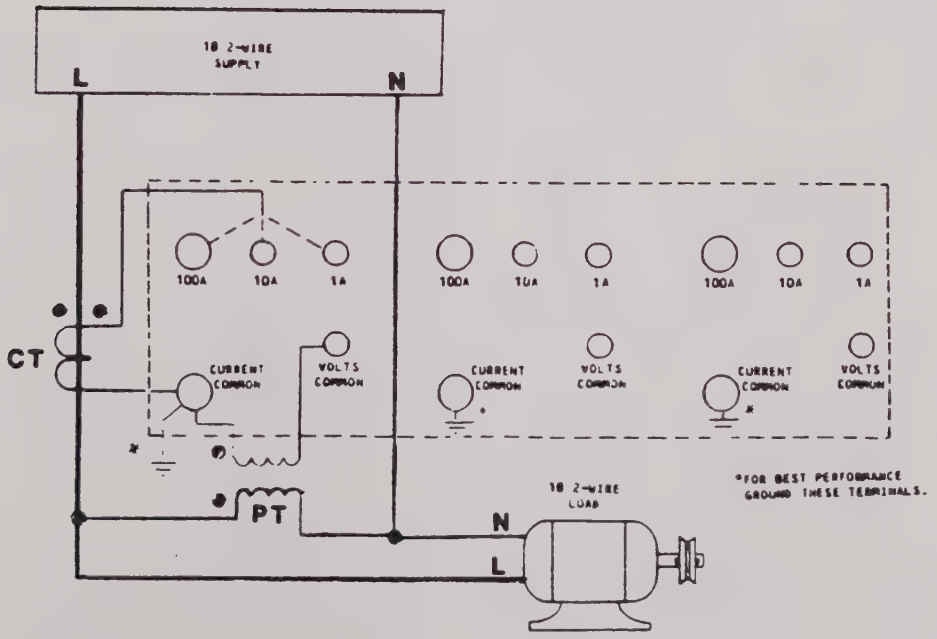


Figure 6-4 Single-Phase Two-Wire CT-PT Load Power Connections

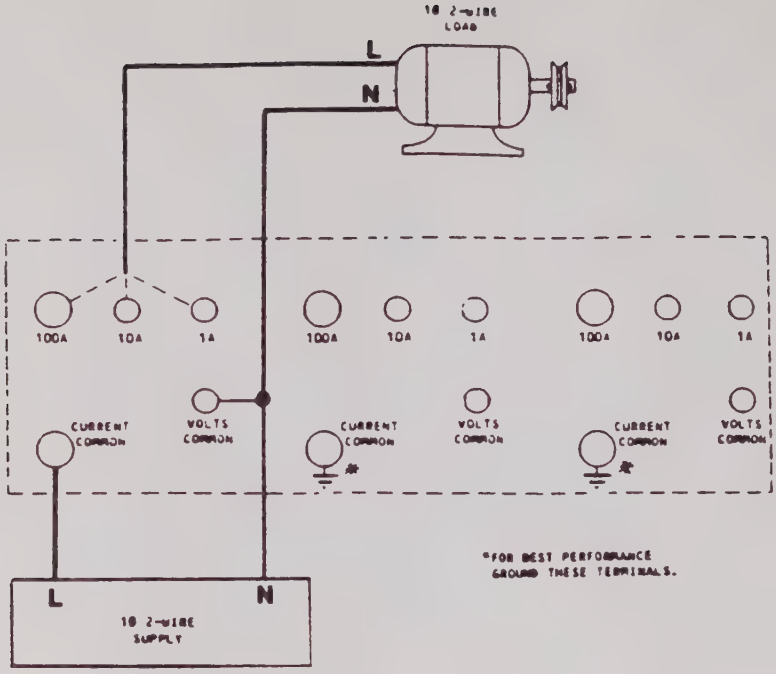


Figure 6-5 Single-Phase Two-Wire Source Power Connections

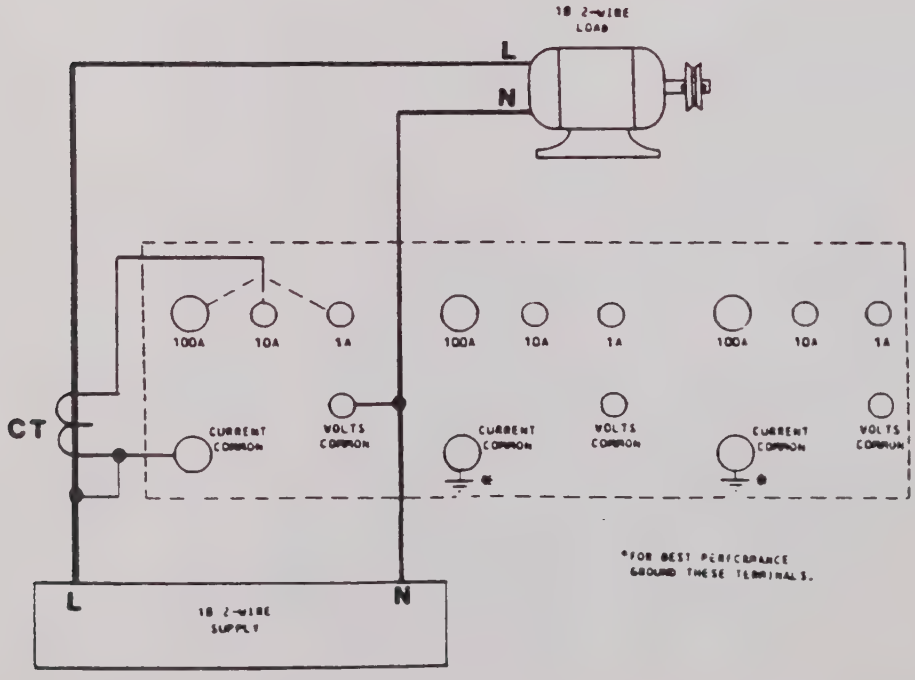


Figure 6-6 Single-Phase Two-Wire CT Source Power Connections

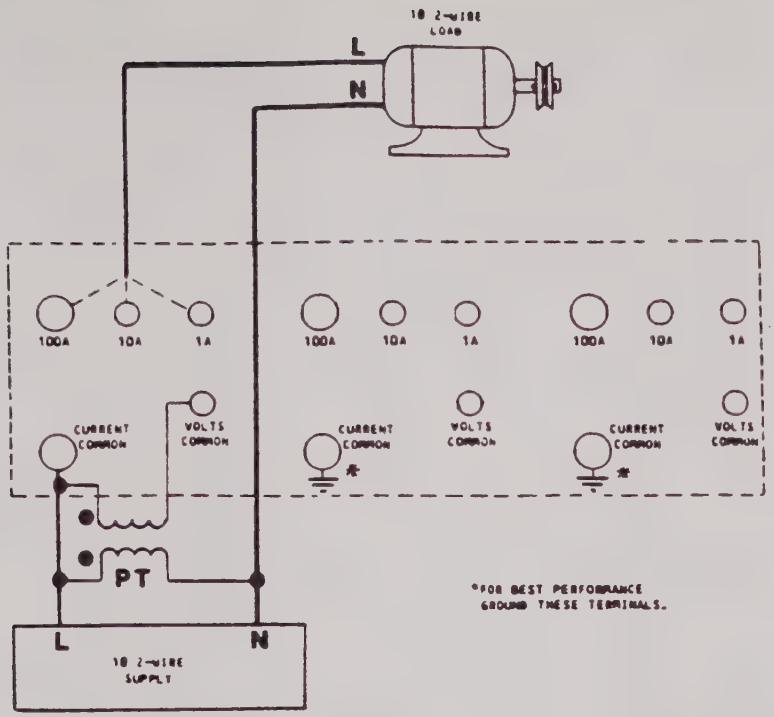


Figure 6-7 Single-Phase Two-Wire PT Source Power Connections

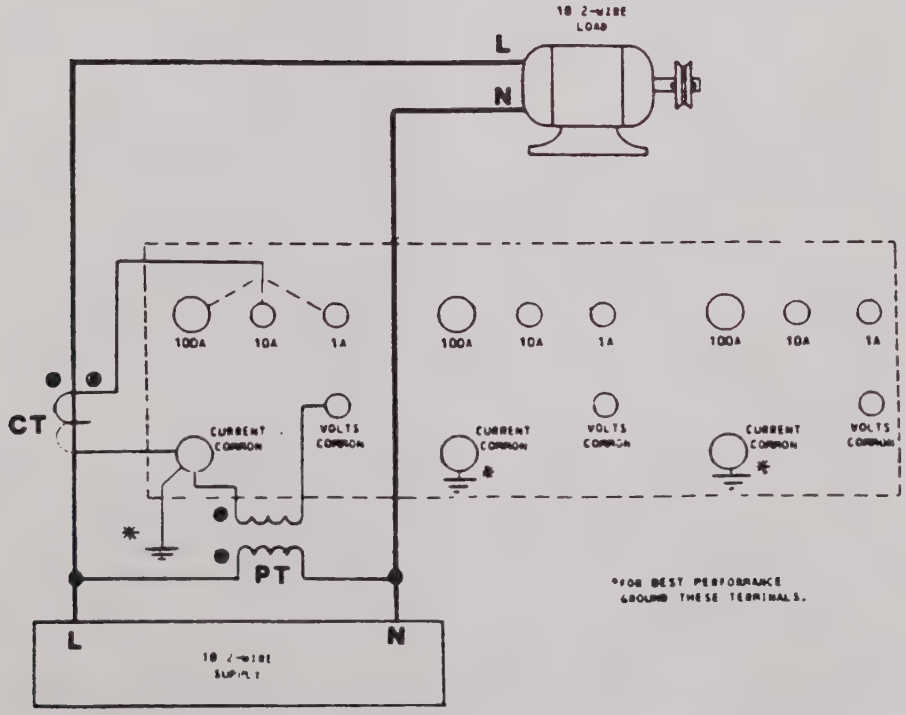


Figure 6-8 Single-Phase Two-Wire CT-PT Source Power Connections

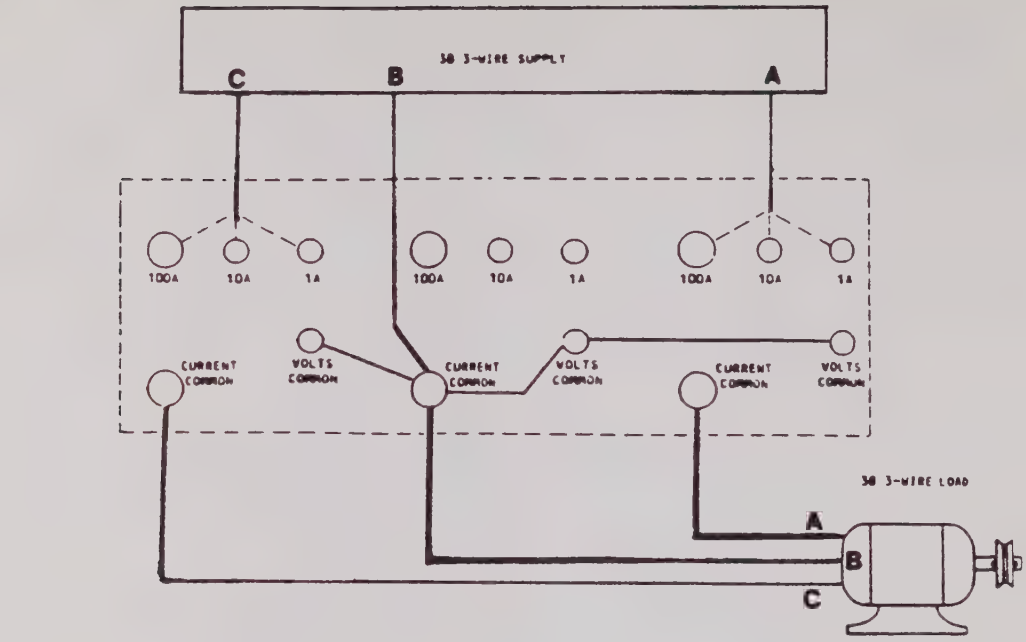


Figure 6-9 Three-Phase Three-Wire Load Power Connections

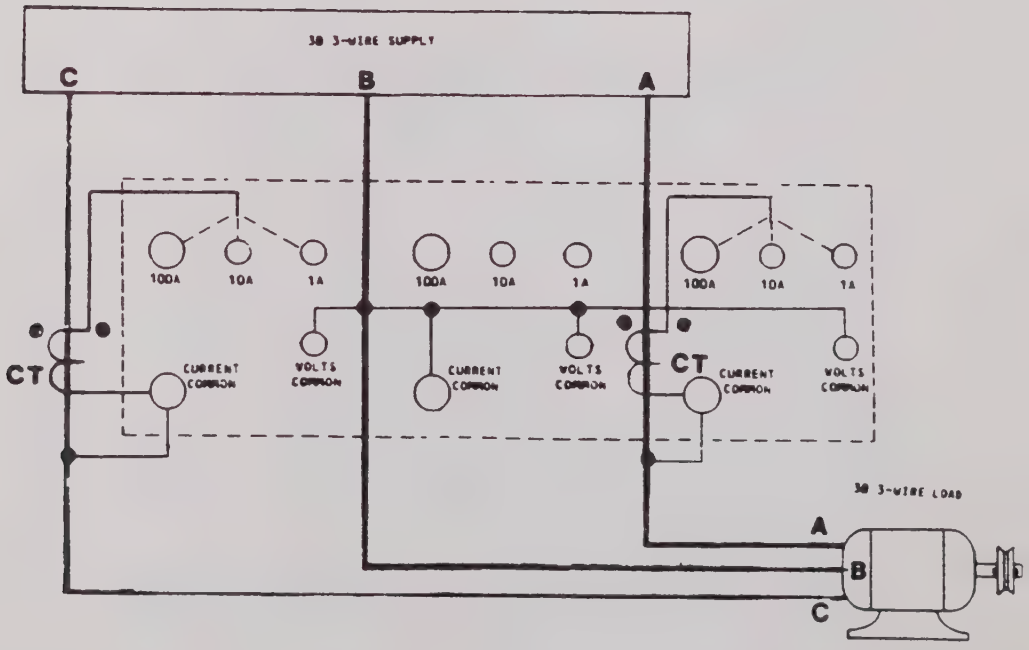


Figure 6-10 Three-Phase Three-Wire CT Load Power Connections

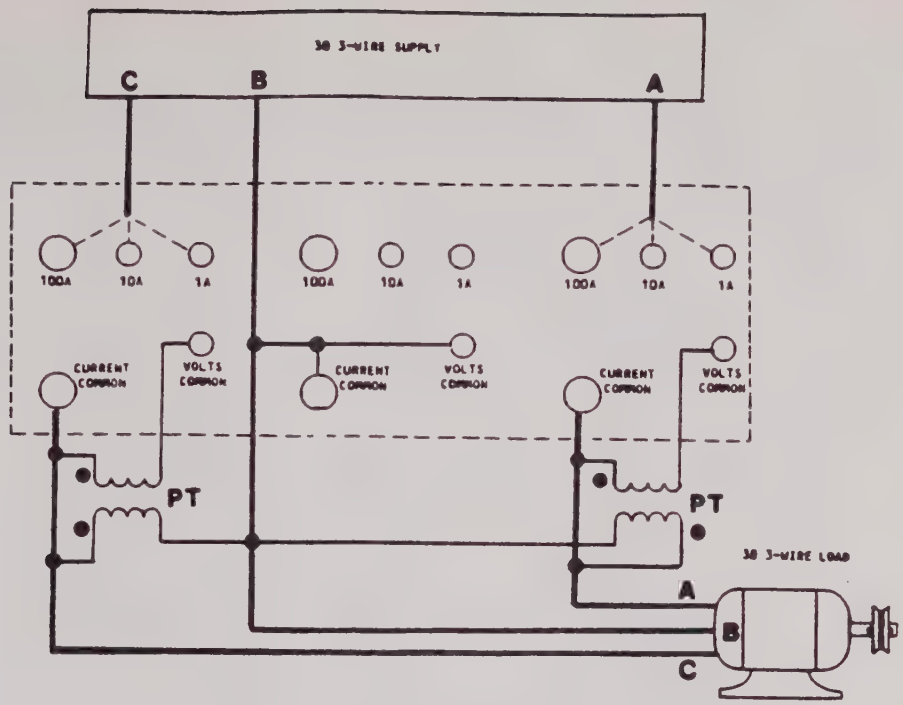


Figure 6-11 Three-Phase Three-Wire PT Load Power Connections

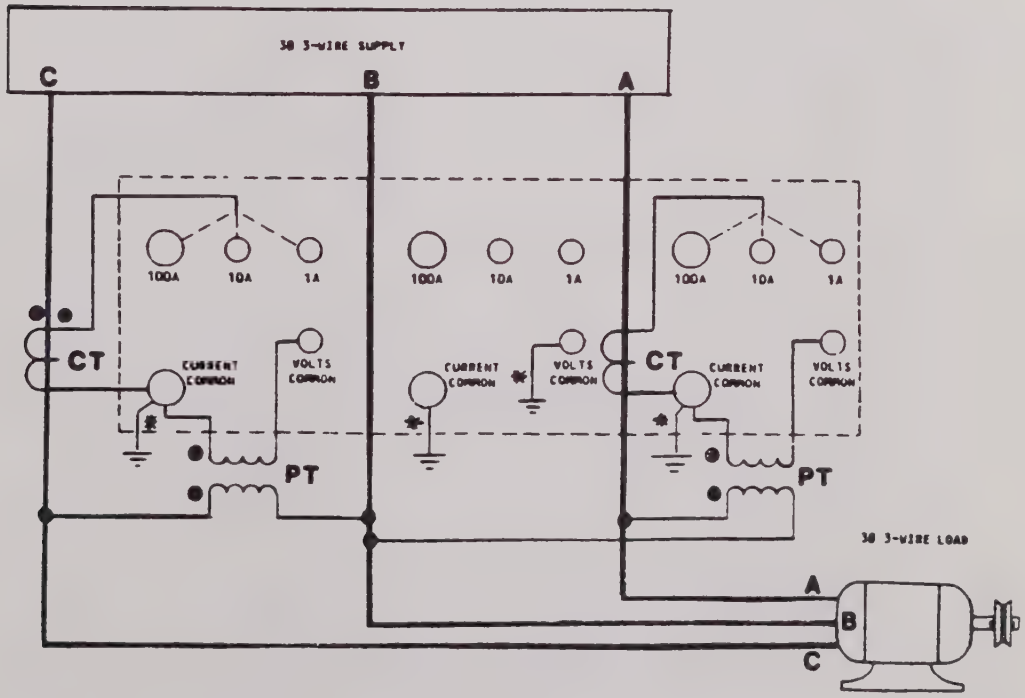


Figure 6-12 Three-Phase Three-Wire CT-PT Load Power Connections

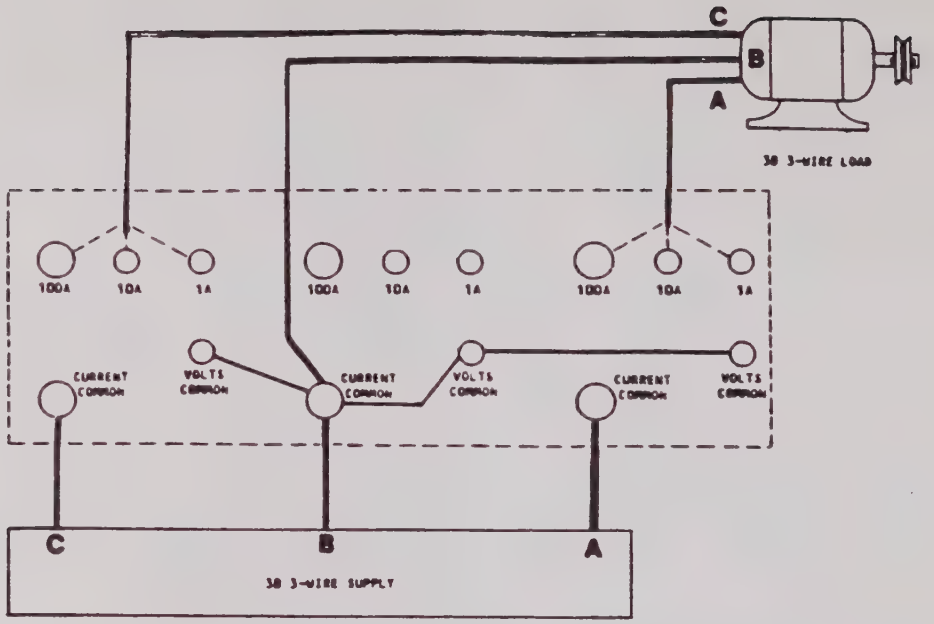


Figure 6-13 Three-Phase Three-Wire Source Power Connections

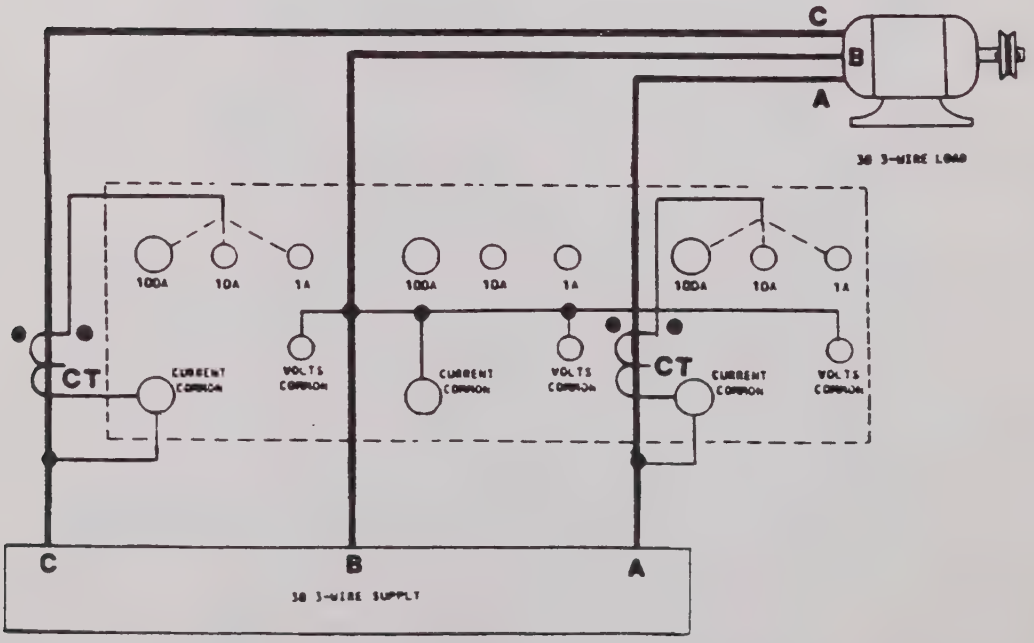


Figure 6-14 Three-Phase Three-Wire CT Source Power Connections

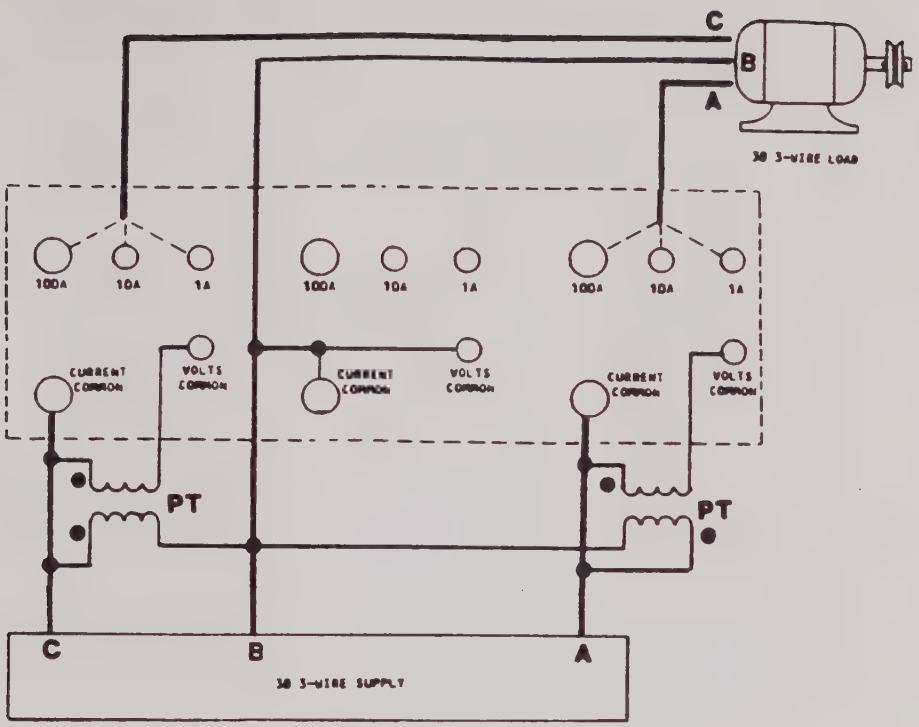


Figure 6-15 Three-Phase Three-Wire PT Source Power Connections

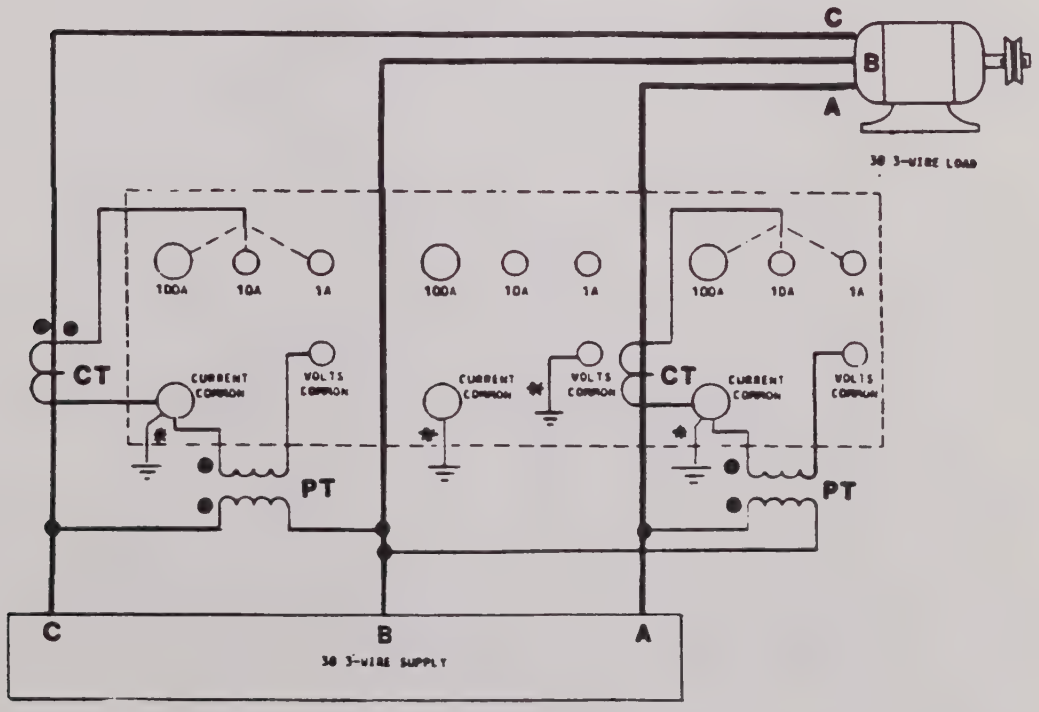


Figure 6-16 Three-Phase Three-Wire CT-PT Source Power Connections

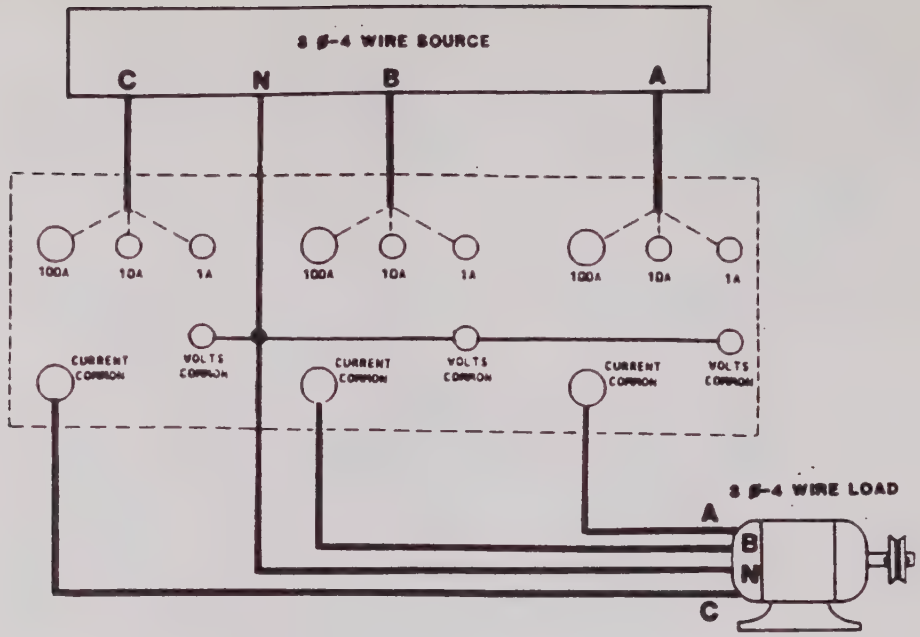


Figure 6-17 Three-Phase Four-Wire Load Power Connections

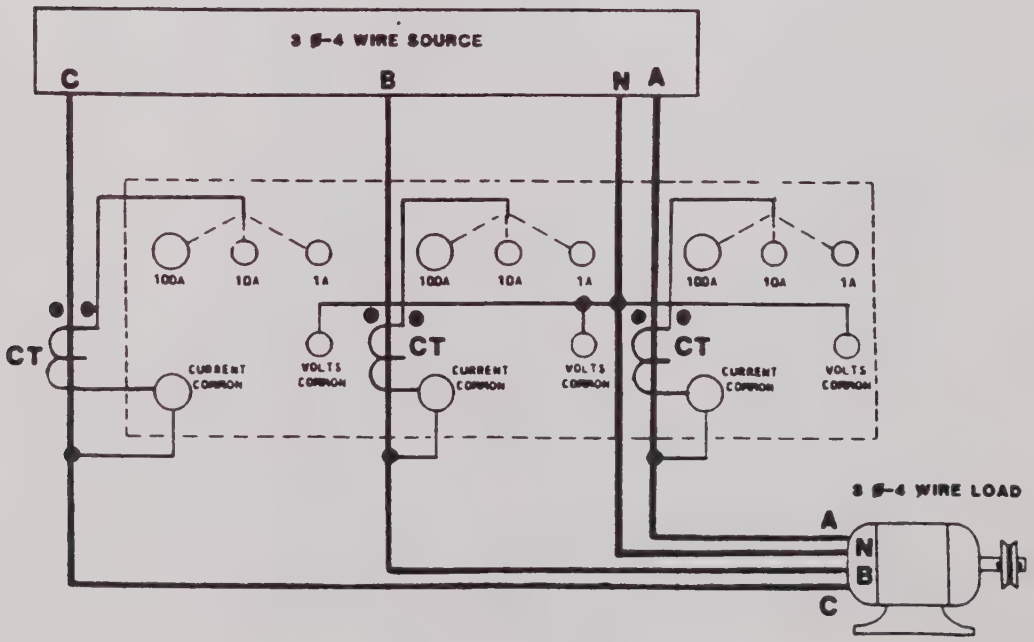


Figure 6-18 Three-Phase Four-Wire CT Load Power Connections

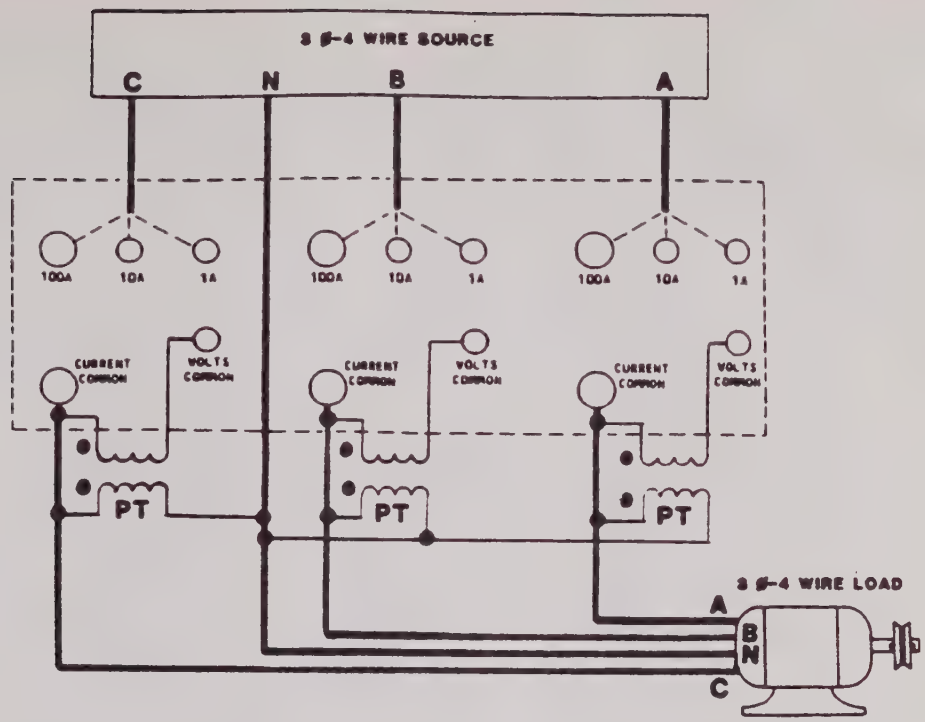


Figure 6-19 Three-Phase Four-Wire PT Load Power Connections

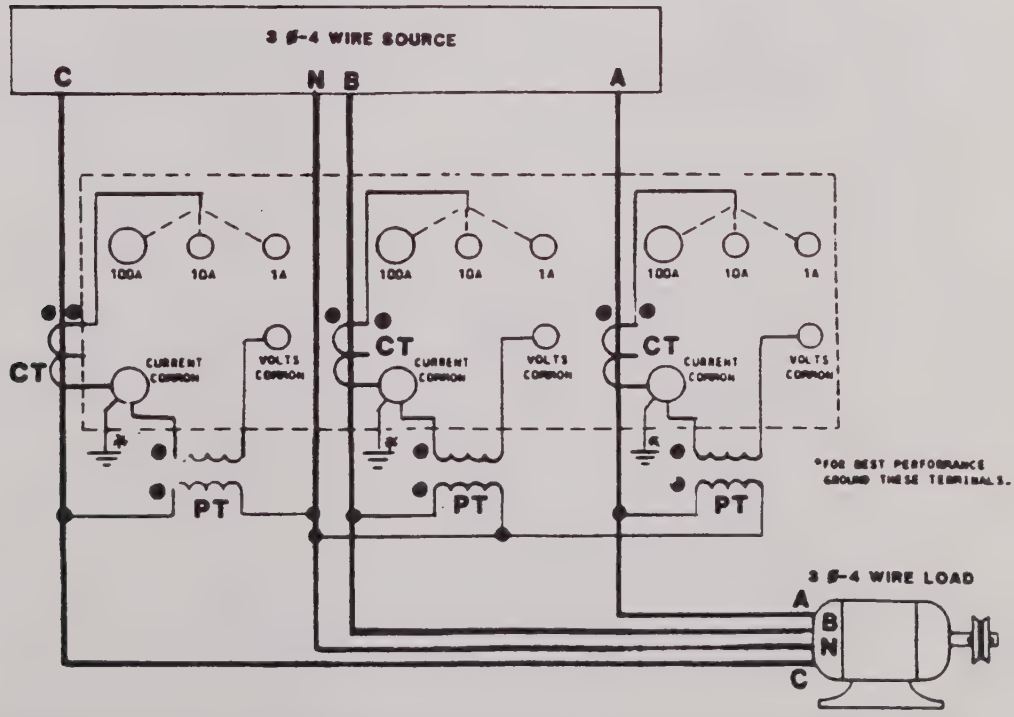


Figure 6-20 Three-Phase Four-Wire CT-PT Load Power Connections

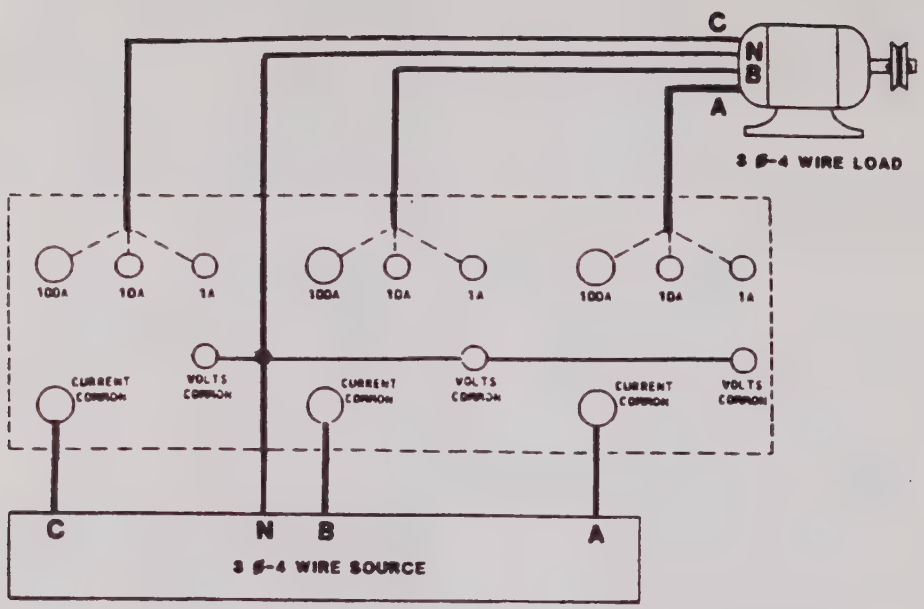


Figure 6-21 Three-Phase Four-Wire Source Power Connections

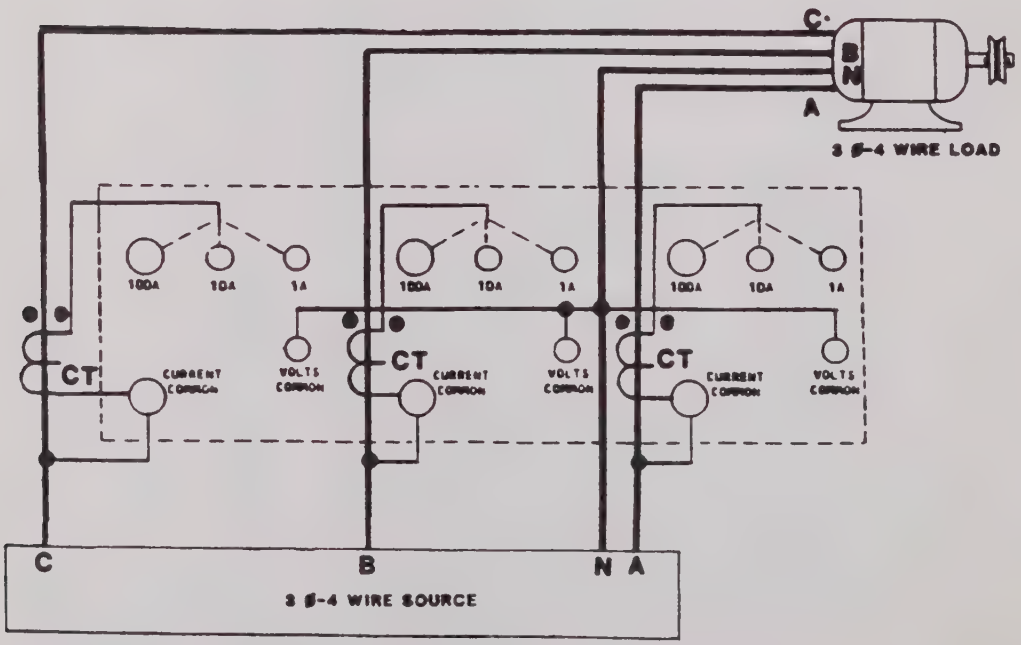


Figure 6-22 Three-Phase Four-Wire CT Source Power Connections

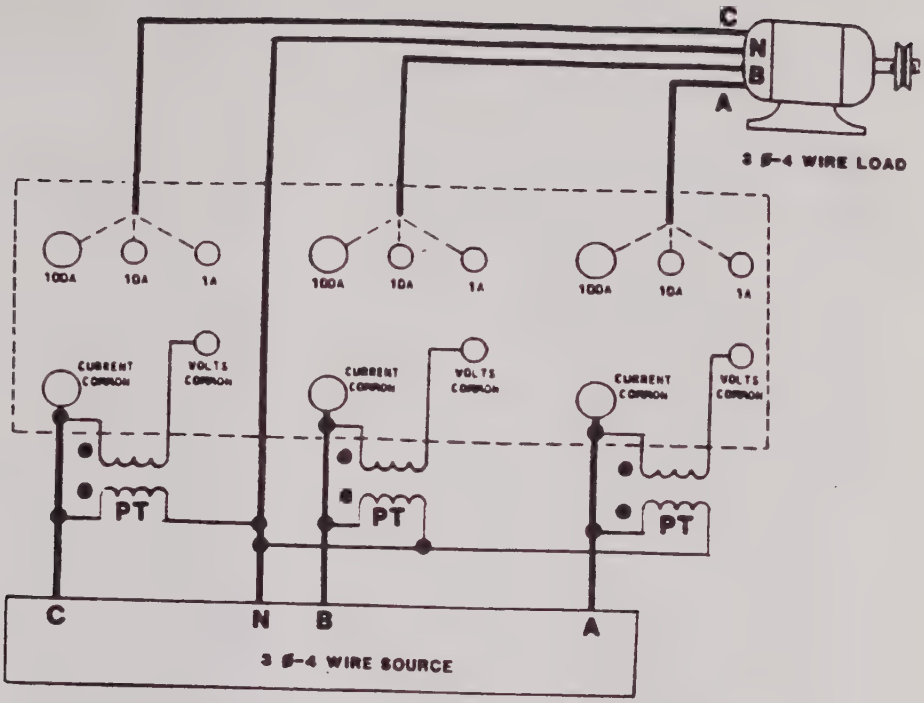


Figure 6-23 Three-Phase Four-Wire PT Source Power Connections

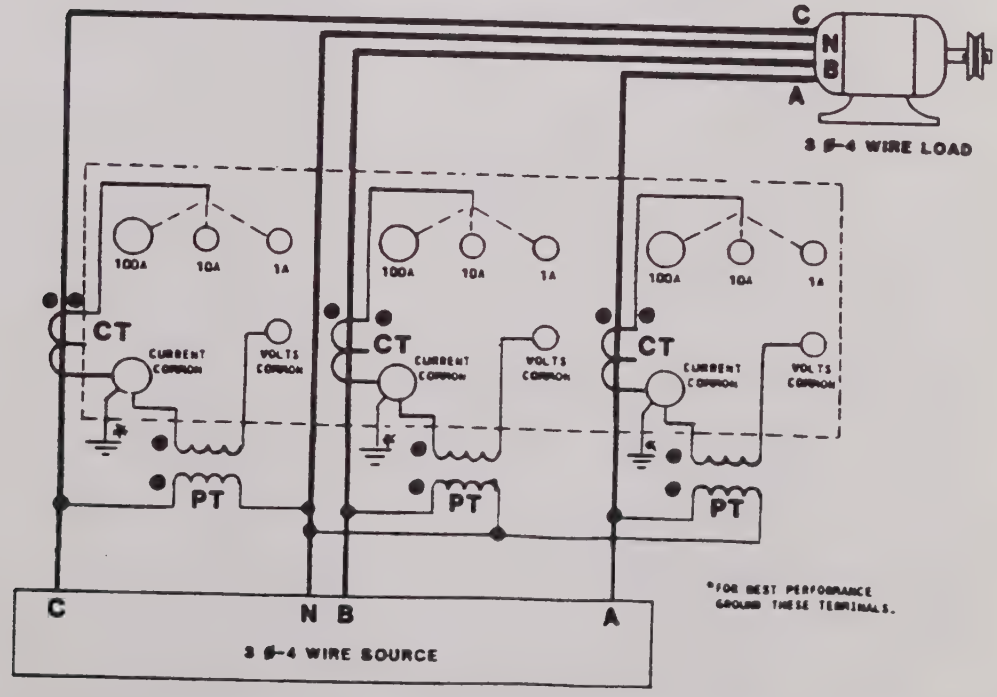


Figure 6-24 Three-Phase Four-Wire CT-PT Source Power Connections

and prompts. In 1-channel units, the rows are still designated as A, B, and C for clarity, although they all contain information regarding channel A only.

The following functions are available in rows "A", "B", and "C". Items marked with "Σ" are also available in the summing row. When in the summing row, these values represent the summation of all channels calculated according to the selected shunt wiring configuration (section 6-6).

VRMS The true RMS value of the voltage waveform

VAVG Average voltage calculation (0.9 x VRMS)

VAVR Voltage averaging calibrated to the RMS scale

ARMS The true RMS value of the current waveform.

AAVG Average waveform calculation (0.9 x ARMS)

A_PK The measured peaks of the current waveform

A_CF Current crest factor calculation (A_PK ÷ ARMS)

A_HR(Σ) Ampere-hours calculation using on-board clock

WATT(Σ) True power in Watts (VRMS x ARMS x cosθ)

VA(Σ) Apparent power calculation (VRMS x ARMS)

VAR(Σ) Reactive power calculation ($\sqrt{VA^2-WATT^2}$)

W_HR(Σ) Watt-hour calculation using on-board clock

PF(Σ) Power Factor calculation (WATTS ÷ VA)

DEG Phase angle calculation ($\cos^{-1}$ of the PF)

OHMS Calculated load impedance |Z| (VRMS ÷ ARMS)

The following functions are available in Channel A or the summing row *only*:

HZ Frequency of the input signal

6-6. Shunt Wiring Configuration

The shunt wiring configuration selection determines the method by which the 2330A will perform its total power calculations. This section does not apply to 1-channel units.

The first step is to determine which wiring style you are using. The choices are: 3-wire-Delta, 4-wire-Y, or (B+C)/A. The default mode is the 4-wire-Y configuration. If this matches your wiring style, or if you are making independent single-phase measurements, you may skip this section.

Selecting a different style will not affect the individual channel measurements, but will affect all calculations of the summing row. To select a different style, follow the steps below:

1) Press the **CNFG** key in the SYSTEM row of the MODE section. A blinking cursor (♦) appears over the first letter of the word Channel.
2) Press ENTER (or the 1 key) to select the channel menu.
3) Using the ◂▸ keys, place the cursor on the wiring style for your application.
4) Press ENTER to select this style and return to the measurement mode.

6-6-1. Effects on Calculations

Selecting a different wiring configuration will affect the method by which calculations in the summing row are performed. The changes are discussed in Application Note AN106 at the back of this manual.

_(A+B+C): Watts in A+B+C mode is calculated as accumulated watts summed from A,B and C. Watt-hours is calculated as accumulated watt-hours summed from A,B and C.

6-7. Voltage and Current Ranges

The 2330A has a choice of four voltage ranges and nine (3 per shunt) current ranges. The voltage ranges are: 600V, 300V, 150V or 50V. The available current ranges are:

100A, 50A, 20A	(high shunt)
10A, 5A, 2A	(medium shunt)
1A, 0.5A, 0.2A	(low shunt)

The 2330A may be set to autorange (default) and will automatically select the best voltage range for the highest input signal measured on any channel. The voltage range must be the same for all three channels A, B, and C.

The 2330A may autorange for current (default), but will remain within the selected shunt. For example, if the input current is 1.5 amps on the 1A range, it will *not* select the medium shunt but will instead indicate an overload condition. The user must manually move connections to the higher shunt. As with the voltage ranges, the current range must be the same for all three channels.

To select and hold a voltage range, follow the steps below:

1) Press the **V** key in the RANGE row of the MODE Section. A menu of the voltage ranges appears.
2) Use the ◂ and ▸ cursor keys to place the flashing ♦ on the desired range.
3) Press the **HOLD** key in the RANGE row to hold the selected range. Note that the DISPLAY/RANGE HOLD indicator illuminates.
4) To return to autoranging, press the **V** key followed by the **AUTO** key.

To select a current range and/or shunt, follow the steps below:

1) Press the **A** key in RANGE row of the MODE section. A menu of the current ranges appears.
2) To select a different shunt, press either the ▴ or ▾ cursor keys until the desired group of ranges is displayed.
3) Use the ◂ or ▸ cursor keys to select the desired range within a shunt.
4) Press the **HOLD** key to hold the selected range. Note that the DISPLAY/RANGE HOLD indicator illuminates.
5) To return to autoranging, press the **A** key followed by the **AUTO** key.

Input power may now be applied to the 2330A.

6-8. Display Functions

This section describes the process of configuring the display for the most organized and informative presentation for your application. No configuration is necessarily "wrong" or "right", but rather it should be organized in a way that best suits your needs. The 2330A will not allow configurations that will yield invalid results. Note that at any time the original default settings may be restored by pressing **RESET** or by cycling power. Note also that all menus may be exited by pressing the **CLEAR** key.

This section is written for a 3-channel unit. When using a 1-channel unit, note that the 2330A automatically places 12 of the most commonly desired measurements on the display. These items may be changed using the procedures that follow if the user thinks of "A",

"B", and "C" as rows of the display and not as channels.

6-8-1. Selecting Functions

As discussed in section 6-5, the display is divided into 4 rows. The top 3 rows are used for individual channel data while the bottom or "summing" row is used for three-phase functions, integration, and for communication between the 2330A and the user.

To change a measurement parameter for a specific row, start by pressing the channel key that corresponds to that row. For example, to change a function of the channel A row, press the key labeled **CHA** in the FUNCTION section. To change an item on the summing row, press the key labeled **Σ** (for summation).

After selecting the channel to be changed, a cursor (flashing ♦) appears in that row. The cursor marks the position (field) that will be changed. Move the cursor to other fields by pressing the ◂ and ▸ keys.

The numeric keys 1-4 may also be used as an alternate method of cursor movement. The numbers correspond to the position of a field within a row. For example, to select the second field from the left, press the **2** key. When used to select menu items in the summing row, this method saves time and eliminates the need to press the **ENTER** key.

Up or down movement requires selection of a different channel using one of the channel keys: **CH A**, **CH B**, **CH C** or **Σ**.

After placing the cursor in the field to be changed, item selection may be made in any of several ways. Perhaps the easiest way is to simply press the corresponding key in the FUNCTION section. The functions were defined previously in section 6-5. If the 2330A requires more information or if there are variables involved, a menu or prompt appears in the summing row. Move the cursor and press **ENTER** or use the numeric keys to select the desired function.

☞ An incorrect key-press or unavailable function is indicated by a double "beep" from the 2330A.

Another method of selecting the necessary function is through use of a scrolling menu system. Select the desired row by pressing **CH A, CH B, CH C,** or **Σ**. Position the cursor on the field to be changed. Use the ▴ and ▾ cursor keys to scroll through the functions that are available in that field. The function is selected when you: a) press **ENTER**, or b) move to another field. An advantage to this method is that the user is given a complete menu of the available functions for that field.

6-8-2. Moving Channels

For simplicity of display and ease of interpretation, the 2330A allows the user to blank or move any of the three channel rows of information. The summing row may not be moved, but may be blanked.

To access this feature of the 2330A, press the **CNFG** key in the MODE section. Move the cursor to **Display** and press **ENTER**. With the cursor on **Order**, press **ENTER**. The cursor appears in the top channel row. Press either **CH A, CH B,** or **CH C** to select the desired item for this row or press the ▾ key to blank this row.

Note that the cursor will only move downwards after a selection is made. If a mistake is made, press the **CLEAR** key and **ENTER** to return to the top of the display. When finished, press **ENTER** to return to the measurement mode. To restore the display to the original order, press the **CLEAR** key while in the measurement mode.

6-8-3. Display Resolution, Rate, Filtering, and Brightness

This section describes changing the 2330A display resolution, update rate, and filtering options.

Display resolution may be selected as either 4, 5 or 6 digits. The default is 5 digits. To access this feature, press the **CNFG** key in the MODE section. Select **Digit** and the desired resolution **5-Digit**, **6-Digit**, or **4-Digit**.

The display update rate may be set at either normal (250ms), slow (300ms), or fast (150ms). This feature provides no filtering, but is intended to make viewing the display easier. Access this feature by pressing the **CNFG** key, then select **Display**, **Rate**, and either **Normal**, **Slow**, or **Fast**.

Display filtering may be selected to provide a "walking window average". The number of readings to be included in this average is set by the following sequence of keys: **CNFG**, then select **Filter** and enter the number of readings to be averaged using the **DATA ENTRY** keypad. The present amount of filtering is indicated in ().

The brightness of the display may be adjusted for better viewing in low light areas. The default is maximum brightness. Access this feature using the following sequence of keys: **CNFG**, then select **Display, Contrast,** and use the ▲▼ cursor keys to adjust the brightness. Press **ENTER** to escape from this screen.

6-8-4. Display Hold Functions

The display hold feature of the 2330A allows freezing of either the entire display, or of individual fields. Integrations (discussed later) are not affected and continue during the hold mode.

To freeze the entire display, simply press the **HOLD** key in the DISPLAY row of the MODE section (not the one in the RANGE row!). When holding, the corresponding indicator illuminates to the right of the display.

To hold an individual field, use the channel select and cursor keys to place the cursor on the field to be held. Press the **HOLD** key in the DISPLAY row of the MODE section. A ⌀ symbol appears next to the frozen field. This method may also be used to free an individual field without releasing the entire display. If the steps above are performed on an already frozen display, only that field is released.

☞ The **HOLD** key acts as a toggle. When pressed, any fields that are free will be frozen, and vice-versa. To clear any hold instructions and return to free-running mode, press the **CLEAR** key. Otherwise, individual releases are necessary.

6-8-5. Minimum and Maximum Display

The 2330A may be instructed to update a field of the display only if it makes a measurement that is higher or lower than the reading that is already indicated.

To access this function, position the cursor on the field to be affected. Press either the **MAX** or **MIN** key in the DISPLAY row of the MODE section, as appropriate. A ↑ or ↓ symbol appears next to the affected field and indicates a maximum or minimum reading, respectively.

The max and min functions will be released globally following a **CLEAR** key-press. To release individual fields, position the cursor on that field and press **MAX** to release a maximum hold and **MIN** to release a minimum hold.

6-8-6. CT and PT Ratios

Although the 2330A has current and voltage ranges sufficient for most applications, situations exist in which the voltage and/or current limits of the instrument may be exceeded. In this case it may be desirable to use a current transformer (CT) and/or voltage transformer (PT). Two types of CT's are available from Valhalla Scientific (see Section 3), but a wide variety are available elsewhere in the industry.

Previously with all Valhalla Power Analyzers it was necessary for the user to translate the indicated measurement to the true measurement according to the CT or PT ratio. The 2330A incorporates a feature that will automatically display the corrected current, voltage and power measurements based on the ratio.

To access this function, select the channel to which the ratio will be applied using either the **CH A, CH B,** or **CH C** key. Press the **RATIO** key in the MODE section. A menu appears. Move the cursor to either **CT_Ratio** or **PT_Ratio** as appropriate and press **ENTER**.

Using the **DATA ENTRY** keypad, enter the ratio of the transformer to be used. The present ratio is indicated in (). Press **CLEAR** to correct an entry or **ENTER** to return to the measurement mode. A ♦ appears in the channel row and the corresponding indicator is illuminated. (A ◊ appears for PT ratios.)

☞ Both a CT and PT ratio may be used simultaneously, and the corresponding indicators will be illuminated. The display diamond will be open or solid depending on whether the last change made was to the CT or PT ratio.

To return both CT and PT ratios to 1:1 without changing other functions, select **Normal** in the ratio menu. The ratios are also returned to 1:1 by a **CLEAR**.

☞ This feature is not available in remote mode. The system controller software may be used to perform the corrective arithmetic instead. Refer to AN102 near the back of this manual.

6-9. Other Functions

This section contains all remaining functions of the 2330A except for remote operation and printer functions. For these items please refer to Section 7.

6-9-1. Amps Peak Detector

This feature may be used to detect the peak current into a load over time, or to measure in-rush current. This function is enabled by selecting **A-PK** for a particular field. The selected display will immediately begin to indicate the value of the highest peak detected. This display may be cleared by pressing the **PKCLR** key in the MODE section.

☞ The A_PK display will indicate 0.000 for a moment while draining the peak detector circuitry.

6-9-2. Watt-hours and Ampere-hours

The 2330A may measure and calculate watt-hours and ampere-hours simultaneously for all three channels and also provide a *total* watt-hour and/or ampere-hour determination in the left two fields of the summing row.

To begin, select **W-Hr** or **A-Hr** in one or more fields and/or channels. Press the red **START** key in the INTEGRATE row of the MODE section. A free-running real-time clock appears in the lower right corner of the display. To stop integration and hold readings,

press the red **STOP** key. Pressing the **START** key again will zero all previous integrations, clear the clock, and start a new integration.

Other functions of the 2330A may be accessed while the integration is running, however certain functions such as ratios may not be changed. The integration must be stopped by pressing the **STOP** key before the clock may be removed from the summing row.

6-9-3. Harmonic Analysis

Many applications require the isolation and measurement of harmonic frequencies that may be riding on the fundamental frequency of a waveform. The 2330A is able to measure these harmonics and present them as either a percentage of the total harmonic distortion, or as a value of current. This feature works exclusively with 60Hz fundamental waveforms, and is available on channel A only.

To access this feature, Select distortion by pressing **HARM**. Distortion may be measured in percent or in amperes RMS. To display distortion in amperes RMS, press **A-RMS** after pressing **HARM.** Pressing **A-RMS** again will return to the distortion in percent display.

The harmonics screen appears which displays the harmonics from the fundamental frequency through the 50th harmonic. The display can be scrolled up or down with the cursor keys.

Escape this screen by pressing **ENTER** or **CLEAR**.

6-9-4. Lead/Lag Detector

The 2330A has the ability to determine the phase relationship between the voltage and current inputs. This phase angle may be displayed in the individual channel fields by selecting the PHASE function. In addition, an indicator to the right of the display is used to signify leading or lagging phase angle, and is triggered by a lagging current on any channel A, B or C.

If the **AMPS LAGGING** indicator is illuminated, the current waveform is lagging behind the voltage waveform on one of the channels (inductive load).

If the **AMPS LAGGING** indicator is dark, the current waveform precedes the voltage waveform on all of the channels (capacitive load).

If this indicator is illuminated, the channel causing the LAG indication may be determined using a **CER?** query. Refer to section 7-2-5-4.

6-9-5. Impedance Function |Z|

The 2330A may calculate the absolute value of the impedance of the load based on the measurements taken for voltage and current and Ohm's Law. Impedance data is highly useful in determining the burden effect of a device on a supply. Impedance also becomes important when making power factor corrections.

This function is selected by placing the cursor on the desired field of a channel row and pressing the **|Z|** key. This function is also available through the menu system by scrolling through the menu with the ▾▴ cursor keys. When the **OHMS** item is reached in the menu, press **ENTER** to select the function.

6-9-6. Self-Test Function

The 2330A includes a feature that will automatically perform an internal test of all digital components including RAM, ROM, memory and interfaces. The test will also check the last calibration date and the integrity of the internal calibration constants. A self-test is performed upon pressing the key labeled **TEST** in the MODE section.

6-9-7. Overload Indicators

The 2330A provides two indicators on the front of the instrument to alert the operator if an over-voltage or over-current condition occurs. The LED's are labeled "VOLTAGE PEAK OVERLOAD" and "AMPS PEAK OVERLOAD".

The 2330A will illuminate the corresponding indicator if the RMS value of the input voltage or current signal exceeds 101% of the range and auto-ranging is either not possible or the range is being held. The indicator will also illuminate if the 2330A detects peaks that are greater than 2.5 times the value of the range.

Note that an overrange condition on any channel will illuminate this indicator. The user may determine which channel caused the overrange indication by issuing the **OER?** query. Refer to section 7-2-5-4.

6-10. Operational Limitations

Several functions of the 2330A are based on calculations using the measured RMS voltage, current and power data. While these calculations are proven for sinusoidal waveforms, their validity does not hold true for non-sinusoidal signals.

The following functions of the 2330A are restricted to sinusoidal waveforms:

VAVG determines the average voltage using an averaging AC converter calculation of 0.9 x the measured value of VRMS.

VAVR determines average voltage calibrated to the RMS scale.

A-CF determines the crest factor of the current waveform using the formula: A_PK ÷ ARMS.

AAVG determines the average current using an averaging AC converter calculation of 0.9 x the measured value of ARMS.

6-11. Saving 2330A Settings (Key Storage)

The flexibility of the 2330A allows many different operating modes to be selected. As a result, the default modes of operation may not be the best configuration for many applications. 2330A's operating with Version "1.06" or higher firmware allow the user to store a sequence of keypresses into non-volatile memory for easy recall.

Prior to implementation of this feature, the user should become familiar with the manual front-panel operation of the 2330A. Once the required series of keypresses or steps has been determined, it may be stored using the macro command. It is recommended that a written sequence of steps be developed before attempting to store the macro.

To store a series of keypresses into non-volatile memory from the front-panel, first make sure that the curser is not displayed in any field. Press the **1** key. The 2330A responds with "Key Storage Started". At this point the 2330A creates a macro file from all subsequent keypresses. Configure the 2330A as desired, using up to 63

keypresses. When the desired configuration has been obtained, press the **+/-** key to end storage. The 2330A responds with "Key Storage Ended". Your mini-program has been stored in non-volatile memory, and will not be lost upon reset or power-up.

The program is recalled by pressing the **CNFG** key, followed by the selection of "Display" and "Recall" from the menus that result. A simple way to remember is to press the keys **CNFG 4 4** . Note that it is not possible to edit the program. A complete new entry must be made in order to affect any change. It is therefore recommended that a written record be kept of the program in order to facilitate editing and/or recreation of the macro file.

Note that if the any of the four arrow keys (↑↓→←) are used in creating the macro, the possibility of error exists upon executing the file. This is due to the fact that the arrow keys will move from the present location of the cursor, *which may or may not be the same as when the macro file was created.*

Example: Two left arrow keys (←←) are used to select the 300V range from the 50V range, and this is stored in the macro. The next time the macro is run, however, the unit is *already* in the 300V range. The 2330A still executes the two left arrow keypresses which selects the 50V range.

This can be avoided by using the numeric keypad to select menu items. In the previous example, the 300V range could have been selected by pressing the following keys: **V HOLD** (to ensure that the unit is set to hold the voltage range, and then **V 2** .

This would have selected the 300V range regardless of the existing range setting.

7-1. General

This section describes the operation of the 2330A Power Analyzer via the various interfaces available. It is assumed throughout this section that the user has read Sections 4 through 6 and is familiar with the manual operation of the 2330A. A LabVIEW® driver for the 2330A is also available. Consult the factory for details.

7-2. GPIB Operation

The 2330A is available with an interface that has been designed to comply with the IEEE 488.1 and 488.2 interfacing standards. A complete description as to the workings and requirements of this standard is beyond the scope of this manual. Interested users should refer to any of several publications on the subject:

a) Tutorial Description of the Hewlett-Packard Interface Bus
(HP part number 5021-1927)
b) ANSI/IEEE Standards 488.1 and 488.2-1987

7-2-1. Connections

The port used to connect the 2330A to the GPIB is shown in Figure 5-1 as item #4. All items in the bus are connected in parallel, or "daisy-chained" so that all devices receive the same set of signals. Figure 7-1 shows bus structure and the connection of several devices on the bus.

The bus consists of:
an 8-bit data bus (DIO1-DIO8)
3 handshake lines (DAV, NRFD, NDAC)
5 control lines (IFC, ATN, SRQ, REN, EOI)

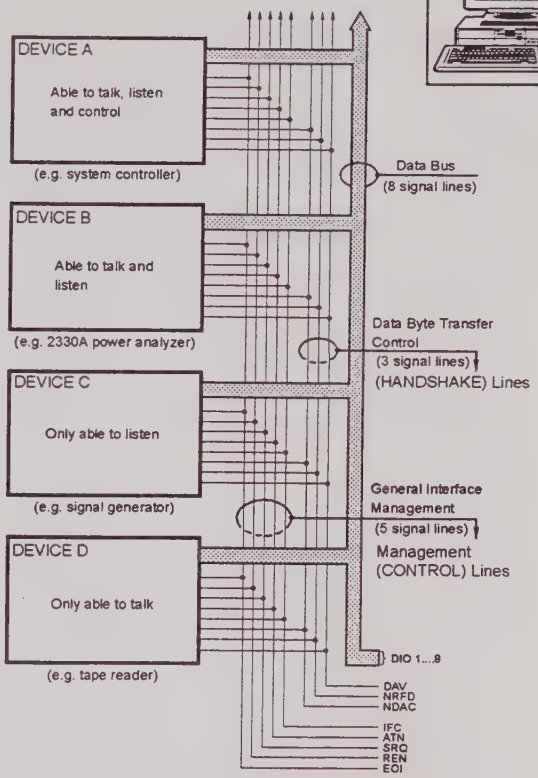


Figure 7-1. GPIB Bus Structure

7-2-2. Setting the Address

Since all items on the bus are connected in parallel, a system had to be designed to tell them apart. The "address" of a device is the method by which the system controller (computer or other device) is able to differentiate one instrument from another. Refer to Figure 7-2.

There are two rules for the assigning of addresses which are listed below:

1) The address of the 2330A may be set to any number from 1 through 30.
2) Each device on the bus must have its own unique address. Operating more than one device at the same address will produce undefined results and is not recommended.

Addr. Char.		Decimal
Talk	Listen	Value
@	SP	00
A	!	01
B	"	02
C	#	03
D	$	04
E	%	05
F	&	06
G	'	07
H	(	08
I	)	09
J	*	10
K	+	11
L	,	12
M	-	13
N	.	14
O	/	15
P	0	16
Q	1	17
R	2	18
S	3	19
T	4	20
U	5	21
V	6	22
W	7	23
X	8	24
Y	9	25
Z	:	26
[	;	27
\	<	28
]	=	29
^	}	30
_	?	31

Figure 7-2. Talk and Listen Addresses

The address of the 2330A is set from the front panel. The factory preset address is 10, and all future examples assume that the 2330A has its address set to 10.

To change the address, press the **ADDR** key in the SYSTEM row of the MODE section. The 2330A indicates the present address in parentheses (). Using the DATA ENTRY keypad, enter the new address and press **ENTER**. The new address is stored in non-volatile memory and will remain at the new value until changed as described above.

7-2-3. Remote and Local States

Local State

When the 2330A is in the "local" state the REMOTE indicator on the front panel is extinguished and full manual control as described in Section 6 may be performed. The user should also note that the 2330A will ignore commands from the GPIB while in the local state.

The 2330A automatically powers-up in the local state. Other methods for placing it in the local state are by pressing the LOCAL key, or by sending a *return to local* (RTL) command over the bus.

Remote State

In this state the REMOTE indicator on the front panel is illuminated and all keys on the front panel are disabled except the LOCAL and RESET keys. The display will not indicate data as it is being provided over the bus.

The remote state may only be entered via the bus. If the 2330A receives its listen address while the REN line is asserted, it will enter the remote state. Placing the instrument into remote is an easy way of verifying that all connections and address selections have been done properly. This may be accomplished in HP Basic using the command: **REMOTE 710** The 2330A should enter the remote state and illuminate the REMOTE indicator. Verify that no other device on the bus was affected by execution of this command.

7-2-4. Sending Commands

The following paragraphs establish guidelines for the manner in which commands shall be sent to the 2330A. Examples are given in HP Basic. If you are using a language other than HP Basic, consult your Programmer's Manual for the correct command syntax.

The 2330A Command Set consists of several types of commands. A complex command may be followed by one or more variables or "arguments". Commands that end with a question mark are "queries", and require that the 2330A provide a response to the query. Other commands are simply setup or configuration instructions, and require no response.

Commands must be sent to the 2330A in the format:

Command <arg1>,<arg2>,..,<argX>

The following rules should be observed when sending commands:

1) The command may be sent using either upper or lower case letters, or a combination of both.
2) A space *must* follow the root command before any arguments, and multiple arguments must be separated by commas (,).
3) Multiple commands (up to 48 characters) may be sent on the same line provided that a semi-colon (;) is used as the command separator.
4) The recognized command line terminators are a ⌙, or a ⌙ with EOI asserted.

A sample program using 2330A commands in HP Basic is shown below. The 2330A is assumed to be at address 10.

```
10    REMOTE 710
20    DIM A$[100]
30    OUTPUT 710;"ARMS? A"
40    ENTER 710;A$
50    PRINT A$
60    LOCAL 710
70    END
```

The RMS value of Channel A current (ARMS) will be contained in A$ and displayed on the computer screen. Numeric responses to queries are in a floating-point scientific notation format similar to:

±x.xxxx e±n

where:

± is either a + or - sign
x are the significant digits of the result
e signifies an exponent
n signifies a power of 10 (i.e. 10^n)

The units of measure of the response will depend upon the query issued. The response will always be in whole units. The possible units are: volts, amperes, watts, hertz, ohms, degrees, percent, and power factor.

All responses to queries that the 2330A provides will include a line terminator. The 2330A terminates all data returned to the controller with a ⌙ and EOI asserted.

7-2-5. 2330A Command Set for GPIB

The following paragraphs contain the complete set of commands recognized by the 2330A. Commands must be sent in the format described previously.

7-2-5-1. Device Commands

This group of commands are used to perform various measurement functions with the 2330A. They may be used to set voltage and current ranges, start and stop integrations, and retrieve measured values.

AAVG? Average Current Query

Syntax: AAVG? <Channel>
where <Channel> = A, B, or C

The AAVG? query returns the average current in amperes for the specified channel.

ARMS? RMS Current Query

Syntax: ARMS? <Channel>
where <Channel> = A, B, or C

The ARMS? query returns the RMS current in amperes for the specified channel.

A_CF? Current Crest Factor Query

Syntax: A_CF? <Channel>
where <Channel> = A, B, or C

The A_CF? query returns the Current Crest Factor for the specified channel. The Current Crest Factor is defined as the ratio of the peak current divided by the RMS current. CF has no units of measure.

A_HR Ampere-Hour Integration Command

Syntax: A_HR <Channel>
where <Channel> = A, B, or C

The A_HR command selects that the ampere-hour function be calculated for the specified channel. See also INTEG.

A_HR? Ampere-Hour Query

Syntax: A_HR? <Channel>
where <Channel> = A, B, or C

The A_HR? query returns two parameters. The first is the value of the integration in ampere-hours. The second is the elapsed time of integration. Note that an integration must be in process in order to use this command. See also A_HR, INTEG.

A_PK? Peak Current Query

Syntax: A_PK? <Channel>
where <Channel> = A, B, or C

The A_PK? query returns the Peak Current measurement for the specified channel. If this query is issued immediately following a PKCLR command, a delay of up to one second may be encountered before the reading is returned. This delay allows the circuit to recharge to the current peak value. See also PKCLR.

DEG? Phase Angle Query

Syntax: DEG? <Channel>
where <Channel> = A, B or C

The DEG? query returns the absolute phase angle in degrees between the voltage and current waveforms. The maximum angle that may be calculated and displayed is 90°.

HZ? Frequency Query

Syntax: HZ?

The frequency query returns the frequency in Hz of the voltage waveform in Channel A.

INTEG Integration Command

Syntax: INTEG <Gate>
where <Gate> = STRT or STOP

The INTEG command starts or stops the current or power integration. See also A_HR, A_HR?, W_HR, and W_HR?.

OHMS? Impedance Query

Syntax: OHMS? <Channel>
where <Channel> = A, B or C

The OHMS? query returns the absolute impedance in ohms calculated from the RMS voltage and current waveforms for the specified channel.

PKCLR Peak Clear Command

Syntax: PKCLR

Upon receipt of this command, the peak circuits are cleared for one second. An additional one second wait is required to restore full peak readings. See also A_PK?.

PF? Power Factor Query

Syntax: PF? <Channel>
where <Channel> = A, B or C

The PF? query returns the Power Factor for the specified channel. Power Factor is the ratio of Watts ÷ Volts x Amps.

RNGE Range Command

Syntax: RNGE <V range>, <I range>, <I shunt>
where <V range> = AUTO, 50, 150, 300, or 600
<I range> = AUTO, 0.2, 0.5, or 1.0
<I shunt> = 1, 10, or 100

The RNGE command selects a specific range for voltage and current measurements. If AUTO is selected, the 2330A automatically selects the range which will provide the best accuracy. The default parameters are AUTO, AUTO, and 1 (autoranging volts and current in the low shunt).

VA? Apparent Power Query

Syntax: VA? <Channel>
where <Channel> = A, B or C

The VA? query returns the apparent power in watts for the specified channel.

VAR? Reactive Power Query

Syntax: VAR? <Channel>
where <Channel> = A, B or C

The VAR? query returns the reactive power in watts for the specified channel.

VAVG? Average Voltage Query

Syntax: VAVG? <Channel>
where <Channel> = A, B or C

The VAVG? query returns the average voltage in volts for the specified channel.

VAVR? Average Voltage (RMS Responding) Query

Syntax: VAVR? <Channel>
where <Channel> = A, B or C

The VAVR? query returns the average voltage in volts adjusted to RMS responding for the specified channel.

VRMS? RMS Voltage Query

Syntax: VRMS? <Channel>
where <Channel> = A, B or C

The VRMS? query returns the true RMS voltage in volts for the specified channel.

WATT? True Power Query

Syntax: WATT? <Channel>
where <Channel> = A, B or C

The WATT? query returns the true power in watts for the specified channel. The response may be positive or negative, depending upon the phase relationship of the voltage to the current.

W_HR Watt-Hour Integration Command

Syntax: W_HR <Channel>
where <Channel> = A, B or C

The W_Hr command configures the specified channel for power integration. See also INTEG and W_HR?.

W_HR? Watt-Hour Query

Syntax: W_HR? <Channel>
where <Channel> = A, B or C

The W_HR? query returns the results of the watt-hour integration for the specified channel. Two parameters are returned: The first is the total watt-hours measured. The second is the elapsed time in hours. See also INTEG and W_HR.

7-2-5-2. Internal Commands

This group of commands is used to query or set up different functions internal to the 2330A operating system.

CAL Store Calibration Date

Syntax: CAL <Date>
where <Date> is the calibration date in the format mm-dd-yyXXX. "XXX" are the initials of the calibration technician.

The day and year are stored in nonvolatile memory and may be retrieved with the CAL? query. See also CAL?.

CAL? Last Calibration Date Query

Syntax: CAL?

The CAL? query returns the calibration date as stored by the CAL command. See also CAL.

---

*IDN? Identification Query

Syntax: *IDN?

This query returns an ASCII string containing four fields: <Mfr>,<Model#>,<Serial#>,<Version>

Example:"VALHALLASCIENTIFIC,2330A,0,1.06"

---

*OPT? Option Identification Query

Syntax: *OPT?

The OPT? query returns the list of options installed in the 2330A.

"Option(s): GPIB(IEEE488.2),PRINTER,RS232"

---

*RST Reset Command

Syntax: *RST

The *RST command initializes 2330A device functions, sets ranging to auto, and clears display attributes.

SETCLK Set System Clock

Syntax: SETCLOCK <Hours>, <Minutes>, <Seconds>, <Day>, <Month>, <Date>, <Year>

where <Hours> = 0 - 23
<Minutes> = 0 - 59
<Seconds> = 0 - 59
<Day> = 1 - 7 (Sunday=1)
<Month> = 1 - 12
<Date> = 1 - 31
<Year> = 199x - 9999

This command sets the 2330A system clock to the supplied time and date parameters. See also TIME?.

TIME? Get System Time

Syntax: TIME?

The TIME? query returns the system time and date.

Example: "hh:mm:ss Wednesday February 14, 1994"

---

*TST? Self-test Query

Syntax: *TST?

The *TST? query initiates a 2330A self-test. A "0" is returned if the self-test passes with no problems detected. A response other than "0" indicates that an error occurred.

7-2-5-3. Synchronization Commands

This advanced group of commands is used to control and monitor the flow of information to the 2330A. They may be used to help design an automated process.

---

*OPC Operation Complete Command

Syntax: *OPC

The *OPC command tells the 2330A to set bit 0 in the Standard Event Status Register when it completes all pending operations.

---

*OPC? Operation Complete Query

Syntax: *OPC?

The *OPC? query tells the 2330A to place an ASCII '1' in the device's output queue when it completes all pending operations.

---

*WAI Wait to Continue Command

Syntax: *WAI

The *WAI command makes the 2330A wait until all the previous commands or queries are complete. The 2330A then continues executing commands that follow the *WAI command.

---

*TRG Trigger Command

Syntax: *TRG

The *TRG command causes the 2330A to store the present A/D converter measurements. The converters continue to run but do not update the memory storage. A *RST command or GPIB Device Clear command clears this state and allows memory storage update to resume.

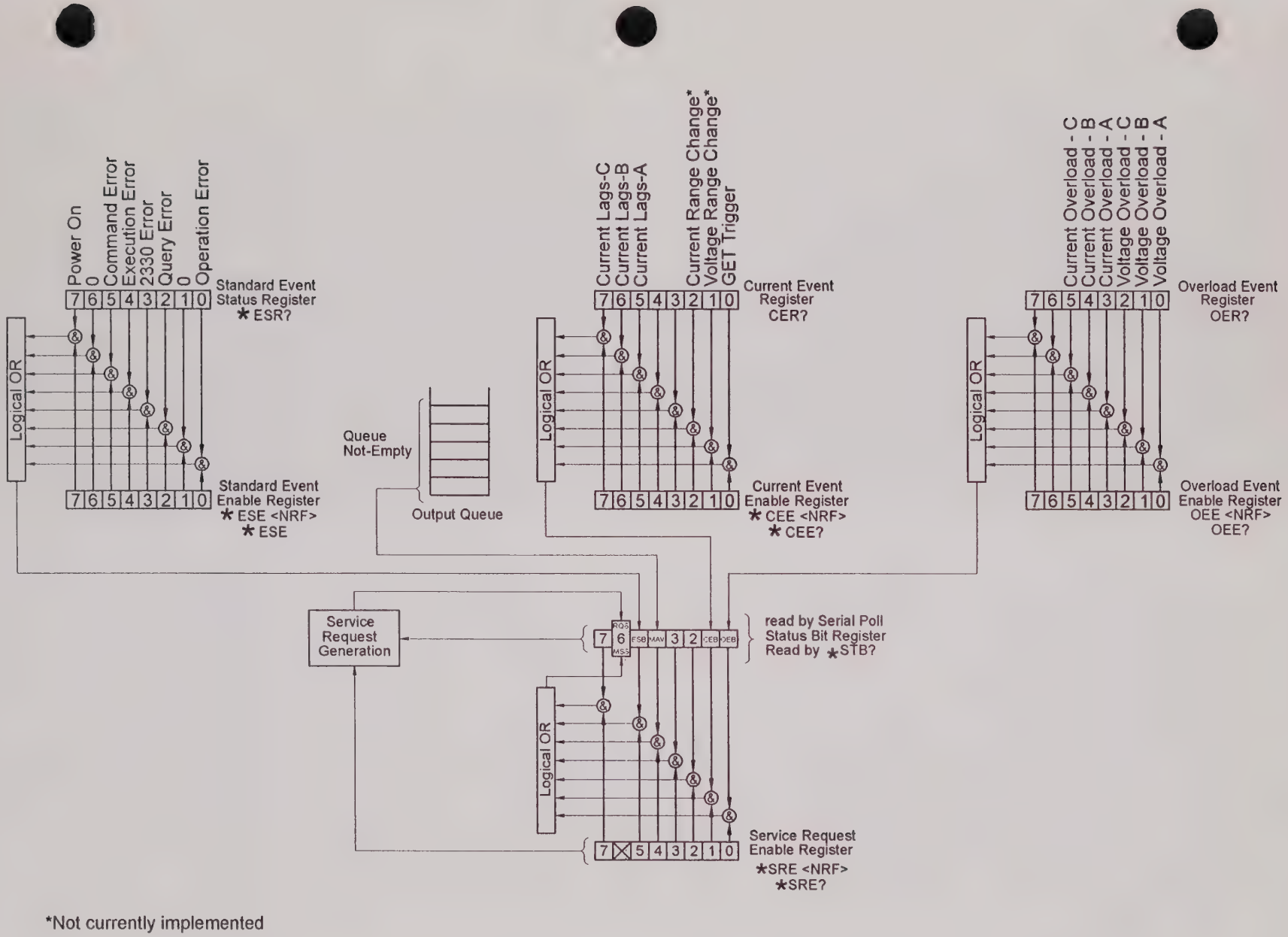


Figure 7-3. 2330A Status Registers

7-2-5-4. Status and Event Commands

The status and event commands provide a means to read and enable events within the 2330A. These commands include reading and writing to the status structures, power-on events and reading the status byte. See Figure 7-3.

---

*CLS Clear Status Command

Syntax: *CLS

The Clear Status Command clears the Standard Event Status Register, Current Event Register, and the Overload Event Register. The corresponding summary bits are cleared in the Status Bit Register. This command does not clear the Output Queue.

---

*ESE Standard Event Status Enable Command

Syntax: *ESE <Mask>
where <Mask> = 0 to 255

The Standard Event Status Enable Command sets the Standard Event Status Enable Register bits. Expressing <Mask> in binary represents the values of the individual bits of the Standard Event Status Enable Register.

---

*ESE? Standard Event Status Enable Query

Syntax: *ESE?

This command reads the contents of the Standard Event Status Enable Register. In response to this query the 2330A sends the contents of the SESER in integer format. It will be in the range of 0 to 255 decimal.

---

*ESR? Event Status Register Query

Syntax: *ESR?

This command reads the contents of the Standard Event Status Register. Reading this register clears it. It returns an integer, which when converted to a binary number represents the contents of the individual bits of the register. This number will be in the range 0 to 255 decimal. The register is described below.

(1)	Bit 0	Operation error
(2)	Bit 1	0
(4)	Bit 2	Query error
(8)	Bit 3	2330A error
(16)	Bit 4	Execution error
(32)	Bit 5	Command error
(64)	Bit 6	0
(128)	Bit 7	Power on

---

*SRE Service Request Enable Command

Syntax: *SRE <Mask>
where <Mask> = 0 - 63 or 128 - 191

This command sets the Service Request Enable Register. This register determines what bits in the Status Byte will cause a service request from the 2330A. Expressing this number in binary represents the values of the individual bits of the Service Request Enable Register.

---

*SRE? Service Request Enable Query

Syntax: *SRE?

This command reads the contents of the Service Request Enable Register. The 2330A returns the data as an integer in the range 0 to 63 or 128 to 191, since bit 6 (the RQS bit) cannot be set.

*STB? Read Status Byte Query

Syntax: *STB?

This command reads the status byte containing the Master Summary Status (MSS) bit. The 2330A responds with an integer in the range 0 to 255. These bits represent the contents of the status byte. Bit 6 represents MSS rather than RQS (Request Service). The status byte is described below.

(1)	Bit 0	Overload Event Bit
(2)	Bit 1	Current Event Bit
(4)	Bit 2	0
(8)	Bit 3	0
(16)	Bit 4	Message Available
(32)	Bit 5	Event Status Bit
(64)	Bit 6	Master Summary Status
(128)	Bit 7	0

CEE Current Event Enable Command

Syntax: CEE <Mask>
where <Mask> = 0 - 255

The Current Event Enable Command sets the Current Event Enable Register bits. Expressing <Mask> in binary represents the values of the individual bits of the Current Event Enable Register.

CEE? Current Event Enable Query

Syntax: CEE?

This command reads the contents of the Current Event Enable Register. In response to this query the 2330A sends the contents of the CEER in integer format. It will be in the range 0 to 255 decimal.

CER? Current Event Register Query

Syntax: CER?

This command reads the contents of the Current Event Register. Reading this register clears it. It returns an integer, which when converted to a binary number represents the contents of the individual bits of the register. This number will be in the range 0 to 255 decimal. The register is described below.

(1)	Bit 0	Group Execute Trigger
(2)	Bit 1	Voltage range change
(4)	Bit 2	Current range change
(8)	Bit 3	0
(16)	Bit 4	0
(32)	Bit 5	Current lagging (CH A)
(64)	Bit 6	Current lagging (CH B)
(128)	Bit 7	Current lagging (CH C)

OEE Overload Event Enable Command

Syntax: OEE <Mask>
where <Mask> = 0 - 255

The Overload Event Enable Command sets the Overload Event Enable Register bits. Expressing <Mask> in binary represents the values of the individual bits of the Overload Event Enable Register.

OEE? Overload Event Enable Query

Syntax: OEE?

This command reads the contents of the Overload Event Enable Register. In response to this query the 2330A sends the contents of the OEER in integer format. It will be in the range 0 to 255 decimal.

OER? Overload Event Register Query

Syntax: OER?

This command reads the contents of the Overload Event Register. Reading this register clears it. It returns an integer, which when converted to a binary number represents the contents of the individual bits of the register. This number will be in the range 0 to 255 decimal. The register is described below.

(1)	Bit 0	Voltage overload (CH A)
(2)	Bit 1	Voltage overload (CH B)
(4)	Bit 2	Voltage overload (CH C)
(8)	Bit 3	Current overload (CH A)
(16)	Bit 4	Current overload (CH B)
(32)	Bit 5	Current overload (CH C)
(64)	Bit 6	0
(128)	Bit 7	0

7-3. Printer Interface

The 2330A is available with a Centronics compatible parallel printer interface for generation of hard copies of measurement data. The **PRINT** key on the 2330A front panel is pressed to perform a screen dump to the printer.

7-3-1. Connections

The port that is used for printer connections is shown in Figure 5-1 as item #5. The mating cable is a standard IBM® Centronics compatible parallel printer cable.

7-3-2. Operation

After making connections, the 2330A is ready for use. A hard copy of the display may be generated at any time by pressing the **PRINT** key in the SYSTEM row of the MODE section.

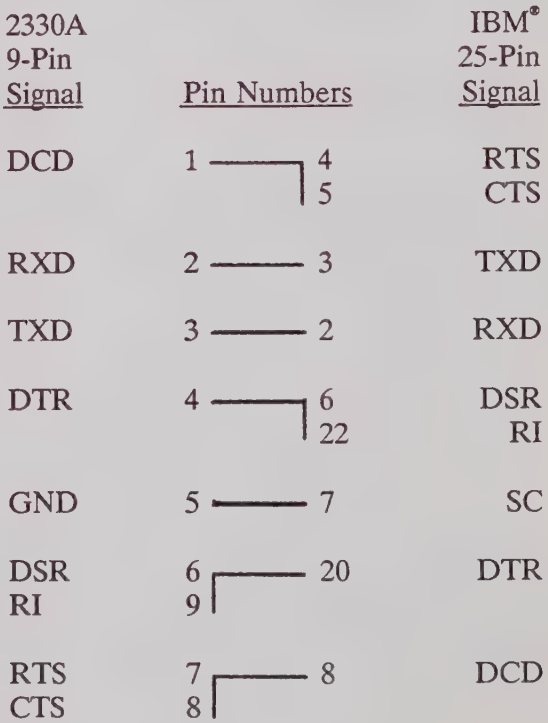
7-4. RS232C Interface

The 2330A is available with an RS232C interface for serial I/O operations. This port is shown in Figure 5-1 as item #6.

7-4-1. Connections

The RS232C port is configured as data terminal equipment (DTE) therefore a null modem cable or adaptor is required to interface to other DTE equipment such as computers and terminals. A "null modem" cable or adapter reverses the roles of various data and control signals to make a DTE device appear as a DCE device or vice versa. Null modem cables may be found at most any computer store, or may be constructed according to the following drawing.

The Null Modem cable:



RS232C pin assignments for the IBM® AT's 9-pin serial connector:

Signal	Pin	Function
DCD	1	Received Line Signal Detect
RXD	2	Received Data
TXD	3	Transmit Data
DTR	4	Data Terminal Ready
GND	5	Signal Ground
DSR	6	Data Set Ready
RTS	7	Request to Send
CTS	8	Clear to Send
RI	9	Ring Indicator

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RS232C pin assignments for the IBM® AT's 25-pin serial connector.

Signal	Pin	Function
GND	1	Protective Ground
TXD	2	Transmit Data
RXD	3	Received Data
RTS	4	Request to Send
CTS	5	Clear to Send
DSR	6	Data Set Ready
--	7	Signal Common
DCD	8	Data Carrier Detect
DTR	20	Data Terminal Ready
RI	22	Ring Indicator
DSRD	23	Data Signal Rate Detector

7-4-2. Sending Commands

Data may be exchanged with the 2330A using the following protocol:

Baud Rate	9600
Parity	none
Word width	8
Stop bits	1
Handshaking	no

Any command sent to the 2330A via the serial port **must be terminated with a semi-colon (;).**

Immediately following a power-up or reset, the ECHO feature *must* be set either to ON by sending a ↵ (carriage return), or set to OFF by sending an ASCII space character. If the 2330A receives any other character before a ↵ or space, it will enter a lockout mode and require a reset. A reset may be initiated by cycling power to the 2330A, pressing the RESET key, or by sending a tilde (~) character to the serial interface. While in lockout mode, the only character that the 2330A will recognize from the serial port is a tilde.

7-4-3. 2330A Command Set for RS232C

The command set for serial operations is essentially the same as discussed previously for GPIB operations except for the differences noted here.

LOCAL Return to Local Command

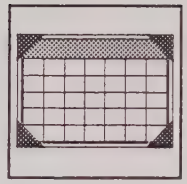
Syntax: LOCAL;

The LOCAL command returns the 2330A from remote to local operation. Note: This command is used only for RS232C operations.

The following commands listed in the GPIB Command Set of section 7-2-5 have no function from the RS232C port:

*CLS
*SRE
*SRE?

SECTION VIII CALIBRATION PROCEDURE



8-1. General

This section provides a calibration procedure for the 2330A Digital Power Analyzer. Calibration should be performed at regular intervals (annually is recommended) to ensure that full instrument accuracy is maintained. The 2330A features a covers-on calibration routine. The internal adjustments are not necessary except following component repair or replacement.

Calibration should be performed with the top and bottom covers installed. It is recommended that the unit be allowed 1 hour for warm-up prior to calibration to achieve temperature stabilization.

8-2. Required Test Equipment

The accuracy of the 2330A is partially dependant upon the accuracy of the equipment used to calibrate it. The following test equipment is recommended for calibration of the 2330A:

1) AC Voltage Calibrator: 1V to 600V, ±0.03% Accuracy (Valhalla 2703 or equivalent)
2) AC Voltage & Phase Calibrator: 0 to 2V, ±0.03% Accuracy (Valhalla 2705 or equivalent)
3) AC Transconductance Amplifier: 0.1A to 100A, ±0.06% Accuracy @ 50-100Hz (Valhalla 2555A or equivalent)
4) If the harmonic analysis function is to be calibrated, a Pragmatic 2411A Arbitrary Waveform Generator or its equivalent

8-3. Description of Procedure

The 2330A uses a digital calibration cycle to maintain its specified accuracy. Throughout this cycle, the 2330A requests specific input signals in order to calibrate internal items such as scaling, linearity, and offset. In all steps, the frequency of the calibration equipment should be set to 100Hz.

It is recommended that the complete cycle be performed whenever a calibration is initiated. Groups of steps such as zeroes, constants, or harmonics may be skipped by pressing **CLEAR** instead of **ENTER** when prompted. It is highly inadvisable to use the RESET key to exit from the calibration routine. This action will most likely corrupt the calibration data and require re-initialization and a full calibration.

A calibration enable switch is used to initiate the calibration cycle. This switch is located behind the front panel. Access is provided through a hole in the tinted black plastic panel. This hole may be covered by a tamper-proof sticker to prevent unauthorized access between calibrations.

Using a **plastic** tool only, press the switch *once*. A single beep will be heard. A single press is used to enable the cycle, but a double press will re-initialize the calibration data to the default state. Never double-press the switch unless it is desirable to reset all calibration constants.

Make connections to the 2330A as shown in Figures 8-1, 8-2, and 8-3 for channel A, B, and C calibration, respectively.

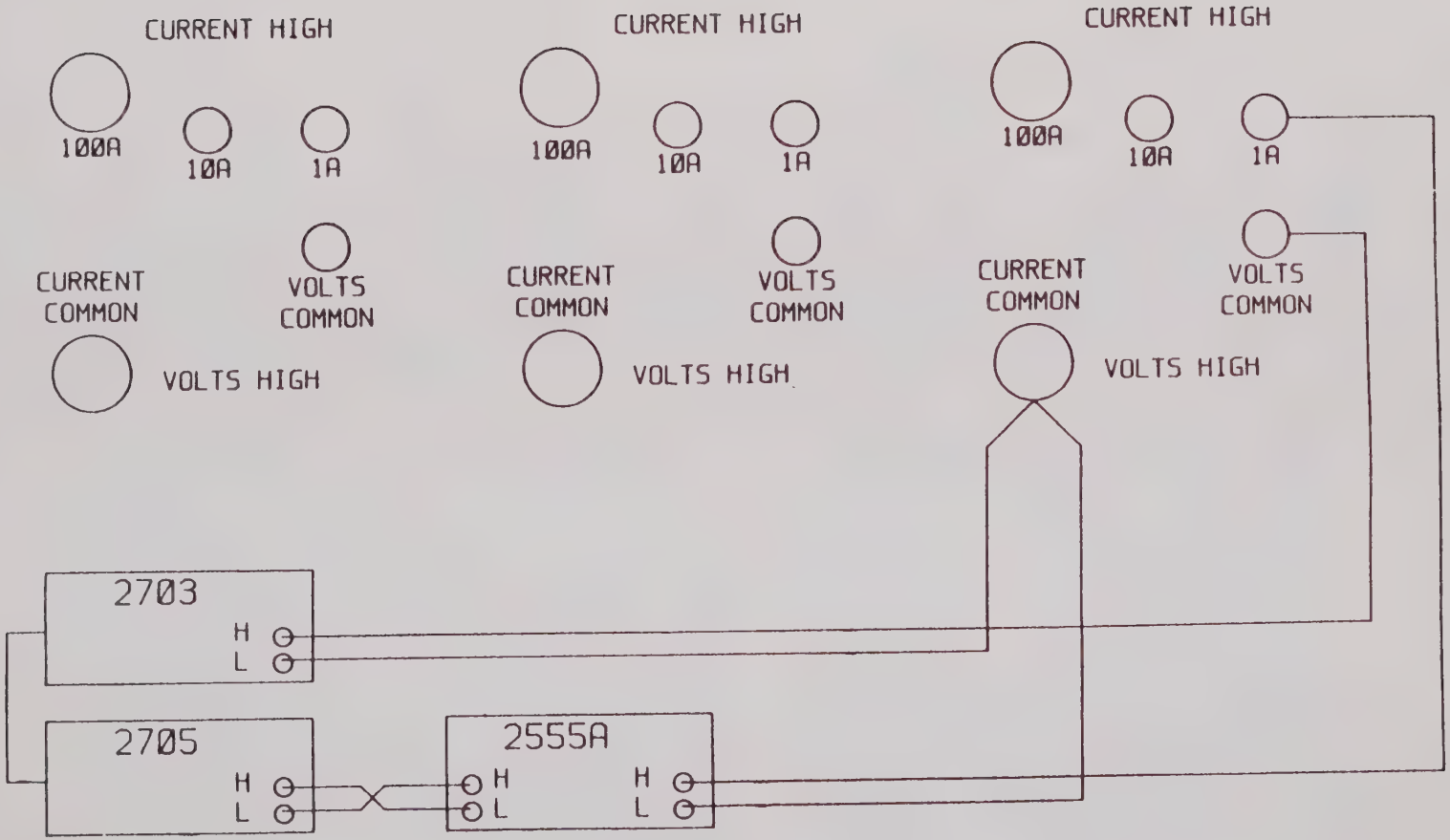


Figure 8-1. CALIBRATION CHANNEL A

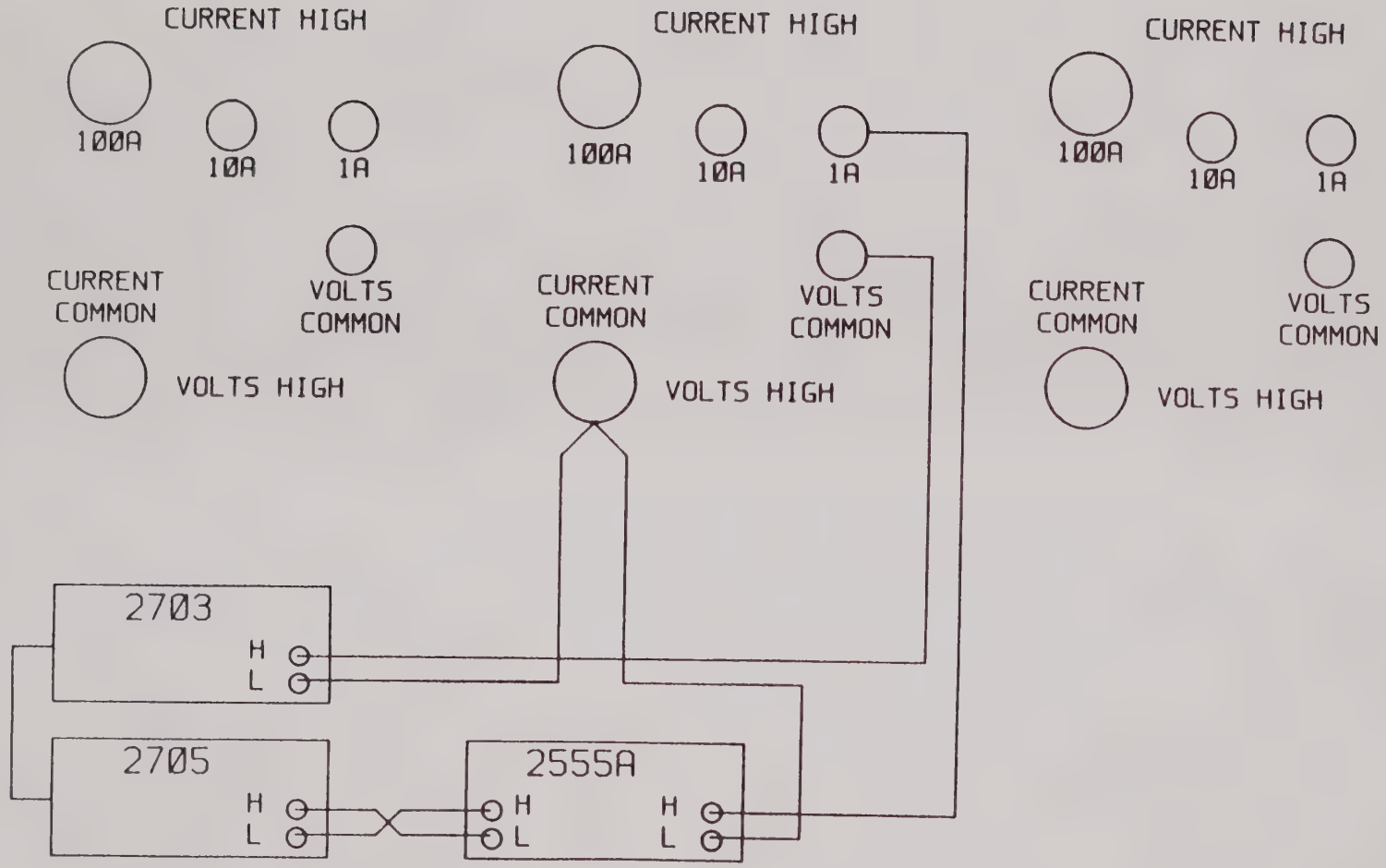


Figure 8-2. CALIBRATION CHANNEL B

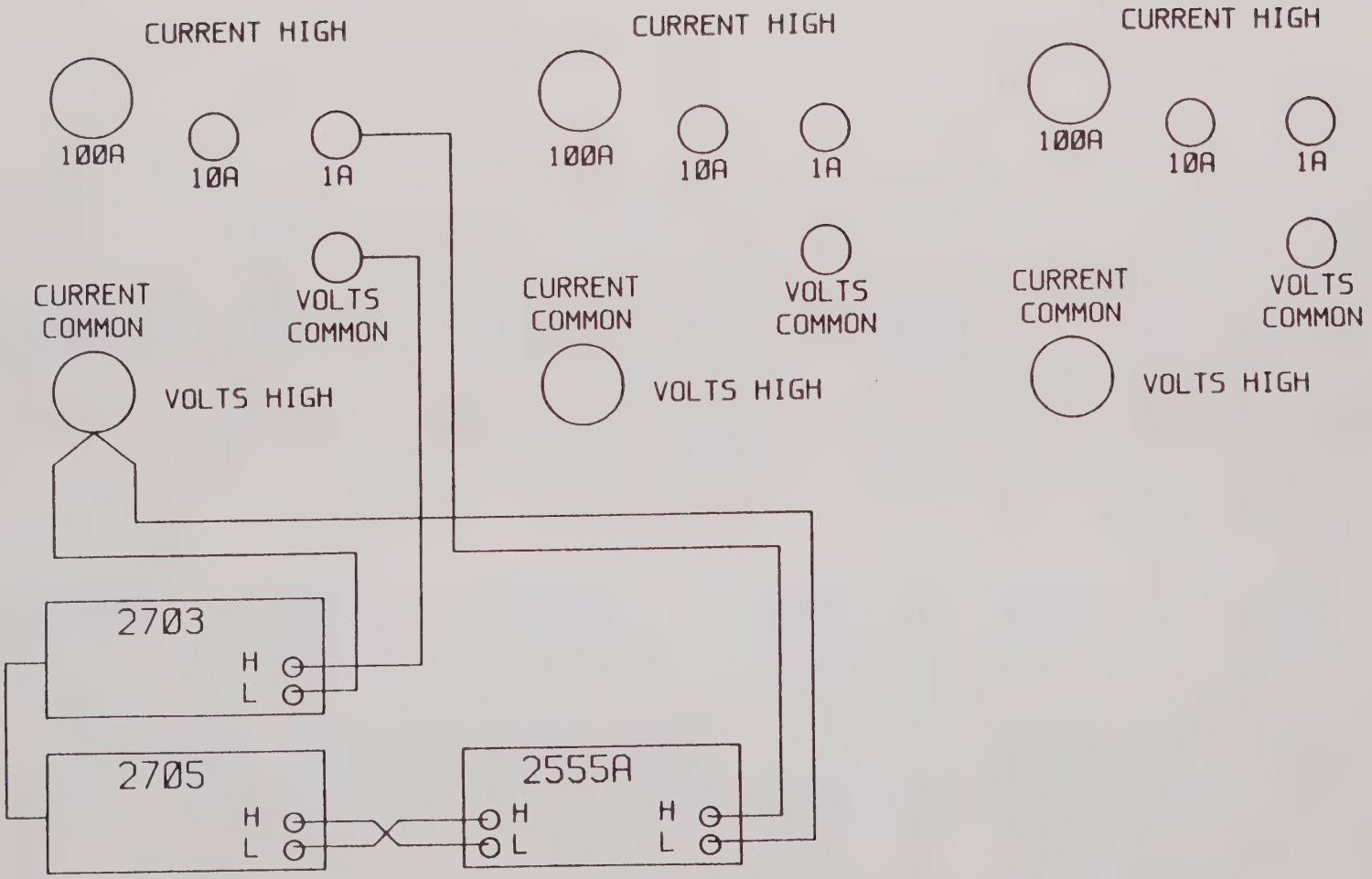


Figure 8-3. CALIBRATION CHANNEL C

8-4. Calibration Cycle

The complete cycle of the 2330A is explained in the following paragraphs. The actual prompts that will appear in the 2330A summing row are given in **bold-face** while the appropriate user action is given below it in *italics*.

After pressing the cal switch once, the 2330A indicates:

CAL to initialize, ENTER to calibrate
Press ENTER.

??V Range Holding (Disables autoranging volts)
??A Range Holding (Disables autoranging amps)
Press ENTER to calibrate zeroes
Press ENTER or CLEAR to skip.

ENTER to calibrate watt zeroes
Press ENTER or CLEAR to skip.

a) **600V / 1A Chan A**
Apply 120 volts and 1 amp to channel A.
Wait for settling and press ENTER.

b) **600V / .5A Chan A**
Apply 120 volts and .5 amps to channel A.
Wait for settling and press ENTER.

c) **600V / .2A Chan A**
Apply 120 volts and .2 amps to channel A.
Wait for settling and press ENTER.

d) **300V / 1A Chan A**
Apply 60 volts and 1 amp to channel A.
Wait for settling and press ENTER.

e) **300V / .5A Chan A**
Apply 60 volts and .5 amps to channel A.
Wait for settling and press ENTER.

f) **300V / .2A Chan A**
Apply 60 volts and .2 amps to channel A.
Wait for settling and press ENTER.

g) **150V / 1A Chan A**
Apply 30 volts and 1 amp to channel A.
Wait for settling and press ENTER.

h) **150V / .5A Chan A**
Apply 30 volts and .5 amps to channel A.
Wait for settling and press ENTER.

i) **150V / .2A Chan A**
Apply 30 volts and .2 amps to channel A.
Wait for settling and press ENTER.

j) **50V / 1A Chan A**
Apply 10 volts and 1 amp to channel A.
Wait for settling and press ENTER.

k) **50V / .5A Chan A**
Apply 10 volts and .5 amps to channel A.
Wait for settling and press ENTER.

l) **50V / .2A Chan A**
Apply 10 volts and .2 amps to channel A.
Wait for settling and press ENTER.

At this point the calibration connections should be moved to channel B. Steps a) through l) will be repeated. Upon completion, move connections to channel C and repeat.

ENTER to calibrate volt zeroes
Move connections to channel A and press ENTER or CLEAR to skip.

m) **Range 600V Chan A**
Apply 120 volts to channel A.
Wait for settling and press ENTER.

n) **Range 300V Chan A**
Apply 60 volts to channel A.
Wait for settling and press ENTER.

o) **Range 150V Chan A**
Apply 30 volts to channel A.
Wait for settling and press ENTER.

p) **Range 50V Chan A**
Apply 10 volts to channel A.
Wait for settling and press ENTER.

Repeat steps m) through p) for channels B and C.

ENTER to calibrate amp zeroes
Move connections back to channel A and press ENTER or CLEAR to skip.

q) **Range 1A Chan A**
Apply .2 amps to channel A.
Wait for settling and press ENTER.

r) **Range 1A Chan A(pk)**
Apply .2 amps to channel A.
Wait for settling and press ENTER.

s) **Range .5A Chan A**
Apply .1 amps to channel A.
Wait for settling and press ENTER.

t) **Range .5A Chan A(pk)**
Apply .1 amps to channel A.
Wait for settling and press ENTER.

u) **Range .2A Chan A**
Apply .04 amps to channel A.
Wait for settling and press ENTER.

v) **Range .2A Chan A(pk)**
Apply .04 amps to channel A.
Wait for settling and press ENTER.

Repeat steps q) through v) for channels B and C.

*****Calibrate all points at 100Hz*****
Press ENTER to calibrate constants
Press ENTER to perform range calibrations.

Press ENTER to calibrate volt constants
Press ENTER or CLEAR to skip.

Apply 600V across Channel A.
Move connections back to channel A and press ENTER.

w) **Range 600V Chan A**
Apply 600V to channel A.
Wait for settling and press ENTER.

Repeat step w) using the requested voltage inputs for the remaining ranges. Move connections and repeat for B and C.

ENTER to calibrate ARMS/APK constants
Press ENTER.

Apply 1A across channel A
Move connections to channel A and press ENTER.

x) **Range 1A Chan A**
Apply 1 amp to channel A.
Wait for settling and press ENTER.

Provide full-scale inputs as prompted for the remaining ranges. Move connections to channels B and C as appropriate.

ENTER to calibrate +watts constants
Press ENTER.

Apply 1A @ 600V across channel A +watts
Make connections to channel A.

y) **1A/600V Chan A**
Apply 1 amp and 600 volts to channel A.
Wait for settling and press ENTER.

Follow the prompts for various combinations of volts and amps. Move connections to channels B and C as appropriate.

ENTER to calibrate -watts constants
Press ENTER.

The subsequent prompts are identical to those of step y) above, however the phase relationship of the input signals should be shifted by 180° (negative watts). Using a Valhalla Model 2705, this is accomplished by selecting 180° phase lead.

☞ If the 2330A indicates "Zero is less than -watts", this means that the phase relationship between voltage and current is incorrect. Recheck connections and press ENTER to clear this message.

Cal complete. Resetting...
Three beeps. End of procedure. ■

8-5. Option IOX Calibration

Option IOX should be calibrated following successful completion of the calibration procedure of Section 8-4. In the following procedure all measurements are made at the IOX connector (shown in Figure 3-1) using a DC voltmeter. The DVM common lead should be connected to any IOX connector common at pins 14 - 24.

Adjustments are accessed by removing the bottom cover of the instrument. **CAUTION! Line voltage is exposed at this point.**

Set the calibration equipment to 100Hz for all steps. All adjustments are made on the IOX PCB.

8-5-1. Phase A IOX Calibration

1) Connect the 2330A as shown in Figure 8-1. Select 150V, 1A ranges HOLD.

2) Apply 150.00 volts and adjust RV12 for an output of 5.000 volts at pin 1 of the IOX connector.
3) Apply 15.00 volts and adjust RV1 for an output of .5000 volts at pin 1 of the IOX connector.
4) Repeat steps 2 and 3 for minimum interaction.

5) Apply 1.0000 amps and adjust RV13 for an output of 5.000 volts at pin 2 of the IOX connector.
6) Apply .1000 amps and adjust RV2 for an output of .5000 volts at pin 2 of the IOX connector.
7) Repeat steps 5 and 6 for minimum interaction.

8) Apply 150.00 volts and 1.0000 amps; adjust RV14 for 5.000 volts at pin 3 of the IOX connector.
9) Apply 15.00 volts and 1.0000 amps and adjust RV7 for .5000 volts at pin 3 of the IOX connector.
10) Repeat steps 8 and 9 for minimum interaction.

11) Apply 150.00 volts and 1.0000 amps; adjust RV15 for 2.500 volts at pin 10 of the IOX connector.
12) Apply 15.00 volts and 1.0000 amps and adjust RV10 for .2500 volts at pin 10 of the IOX connector.
13) Repeat steps 11 and 12 for minimum interaction.

14) Apply 150.00 volts and 1.0000 amps and adjust RV16 for 1.666 volts at pin 11 of the IOX connector.
15) Apply 15.00 volts and 1.0000 amps and adjust RV11 for .1666 volts at pin 11 of the IOX connector.
16) Repeat steps 14 and 15 for minimum interaction.

8-5-2. Phase B IOX Calibration

1) Connect the 2330A as shown in Figure 8-2. Select 150V, 1A ranges HOLD.

2) Apply 150.00 volts and adjust RV17 for 5.000 volts at pin 4 of the IOX connector.
3) Apply 15.00 volts and adjust RV3 for .5000 volts at pin 4 of the IOX connector.
4) Repeat steps 2 and 3 for minimal interaction.

5) Apply 1.0000 amps and adjust RV18 for 5.000 volts at pin 5 of the IOX connector.
6) Apply .1000 amps and adjust RV4 for .5000 volts at pin 5 of the IOX connector.
7) Repeat steps 5 and 6 for minimal interaction.

8) Apply 150.00 volts and 1.0000 amps and adjust RV19 for 5.000 volts at pin 6 of the IOX connector.
9) Apply 15.00 volts and 1.0000 amps and adjust RV8 for .5000 volts at pin 6 of the IOX connector.
10) Repeat steps 8 and 9 for minimal interaction.

11) Apply 150.00 volts and 1.0000 amps and adjust RV20 for 1.666 volts at pin 11 of the IOX connector.

8-5-3. Phase C IOX Calibration

1) Connect the 2330A as shown in Figure 8-9. Select 150V, 1A ranges HOLD.

2) Apply 150.00 volts and adjust RV21 for 5.000 volts at pin 7 of the IOX connector.
3) Apply 15.00 volts and adjust RV5 for .5000 volts at pin 7 of the IOX connector.
4) Repeat steps 2 and 3 for minimal interaction.

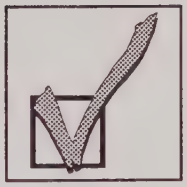
5) Apply 1.000 amps and adjust RV22 for 5.000 volts at pin 8 of the IOX connector.
6) Apply .1000 amps and adjust RV6 for .5000 volts at pin 8 of the IOX connector.
7) Repeat steps 5 and 6 for minimal interaction.

8) Apply 150.00 volts and 1.0000 amps; adjust RV23 for 5.000 volts at pin 9 of the IOX connector.
9) Apply 15.00 volts and 1.0000 amps and adjust RV9 for .5000 volts at pin 9 of the IOX connector.
10) Repeat steps 8 and 9 for minimal interaction.

11) Apply 150.00 volts and 1.0000 amps and adjust RV24 for 2.500 volts at pin 10 of the IOX connector.

12) Apply 150.00 volts and 1.0000 amps and adjust RV25 for 1.666 volts at pin 11 of the IOX connector.

SECTION IX MAINTENANCE



9-1. Periodic Maintenance

The 2330A requires little periodic maintenance other than regular performance of the calibration procedure of Section 8. Other maintenance which may be required is discussed in the following paragraphs.

9-2. Cleaning

It is recommended that the 2330A be operated in a clean environment. However, if the environment is dusty periodic cleaning of the unit will be necessary.

Loose dirt or dust which has collected on the exterior surfaces of the 2330A may be removed with a soft cloth or brush. Any remaining dirt may be removed with a soft cloth dampened in a mild soap and water solution. **Do not use abrasive cleaners.**

The front panel may be cleaned with a soft cloth and a "Windex" type cleaner. **Do not use petroleum based cleaners on the front panel.**

If required, the 2330A interior may be cleaned by blowing with dry compressed air.

If the 2330A has become heavily soiled with dirt or by other contaminants it is recommended that the unit be completely overhauled. Contact your local Valhalla Scientific Service Center for details.

9-3. Tightening

Tightness of connections to the input terminals is important for safety and reliability of measurements. Loose connections, especially when working with high current levels, may cause excessive temperatures to build up on the shunt input terminals. This contact resistance also requires the source to supply additional power in order to overcome it. It is recommended that power be removed and the integrity of connections periodically checked as they may have become relaxed.

SECTION X SPECIAL APPLICATION NOTES

The following pages contain notes specific to certain applications. Review of these notes is recommended in order to obtain maximum utility and safety from the Model 2330A Power Analyzer. The topics are listed below.

AN101 Protecting the 2330A from Inductive Loads

Figure 1. Single-phase Inductive Load Protection (Method 1)
Figure 2. Three-phase Three-wire Inductive Load Protection (Method 1)
Figure 3. Three-phase Four-wire Inductive Load Protection (Method 1)
Figure 4. Single-phase Inductive Load Protection (Method 2)
Figure 5. Three-phase Three-wire Inductive Load Protection (Method 2)
Figure 6. Three-phase Four-wire Inductive Load Protection (Method 2)

AN102 Using Current and Potential Transformers (CT's and PT's)

Figure 1. Current Transformer Connections
Figure 2. Potential Transformer Connections
Figure 3. Current Transformer/Potential Transformer Connections

AN103 Source Power Measurements

Figure 1. Load Power Connections
Figure 2. Source Power Connections
Figure 3. Lead Resistance Error Sources
Figure 4. Minimizing Error Sources

AN104 Measuring Phase Currents in 3-Wire Systems

Figure 1. Three-phase Three-wire Standard Connections
Figure 2. Alternate Three-phase Three-wire Connections

AN105 Measuring Transformer Loss with the 2330A

Figure 1. Transformer Loss Connections

AN106 Measuring Power Factor and Reactive Volt Amperes

Figure 1. Watts, VA's, VAR's and PF

AN107 Minimizing Error Sources Using Three-Wire Connections

Figure 1. Three-wire Digital Power Analyzer
Figure 2. Digital Power Analyzer Error Sources
Figure 3. Error Source Reduction
Figure 4. Measuring Power Loss in Connecting Leads

AN108 Measuring Single-Phase Three-wire Power

Figure 1. Single-phase Three-wire Power
Figure 2. Single-phase Three-wire Connections
Figure 3. Alternate Single-Phase Three-wire Connections

APPLICATION NOTE AN101
PROTECTING THE 2330A DIGITAL POWER ANALYZER FROM INDUCTIVE LOADS

101-1. General

The 2330A Power Analyzer is ideally suited for measuring the power drawn or supplied by large electric motors, generators, transformers, or other types of inductive devices. The testing of highly inductive loads such as these requires that precautions be taken to protect the 2330A from damage due to inductive kickbacks. Very high voltage spikes may be produced when the motor or transformer is disconnected from the source. Spikes may also be produced when a resistive load is disconnected from an inductive source, e.g. a transformer or generator. These spikes can easily exceed the common mode and series mode specifications of the 2330A.

101-2. Protection Methods

There are two methods of protecting the 2330A from inductive kickbacks. These methods are described in the following paragraphs.

101-2-1. Switch Protection

In this method a switch is placed between the 2330A and the inductive load. When disconnecting, the load switch SW1 should be opened first. Switch SW2 can now be opened, disconnecting the 2330A from the source. Figures 1, 2 and 3 detail this type of protection for single and three-phase loads.

101-2-2. Spark Gap Protection

In many cases the switch protection method is not practical. Spark gap protection is the preferred method of protecting the 2330A from inductive kickbacks because the protection is not dependent on the operator. The spark gap(s) dissipate the energy from the inductive kickback. Figures 4, 5 and 6 detail this type of protection for single and three-phase connected loads. When the source is also inductive, e.g. a generator, additional spark gaps should be used. In all cases the spark gaps should be connected close to the load (source) and as far from the 2330A as practical.

All connections should be made using heavy gauge wire. The spark gap voltage rating should be selected at two to four times the working voltage, 1500 volts maximum. The energy rating in joules depends on the load. For motors, a good rule of thumb is 10 joules per horsepower. For transformers, the energy rating can be calculated from the equation:

$$ENERGY = \frac{1}{2}(LI^2)$$

Where:

Energy =	the stored energy in the inductor in Joules
L =	the inductance in Henries
I =	the current used to charge the inductor (supply current) in amps

If the inductance of the transformer is estimated, use a spark gap of higher energy rating than calculated for a margin of safety. Spark gaps are available from C.P. Clare, among others.

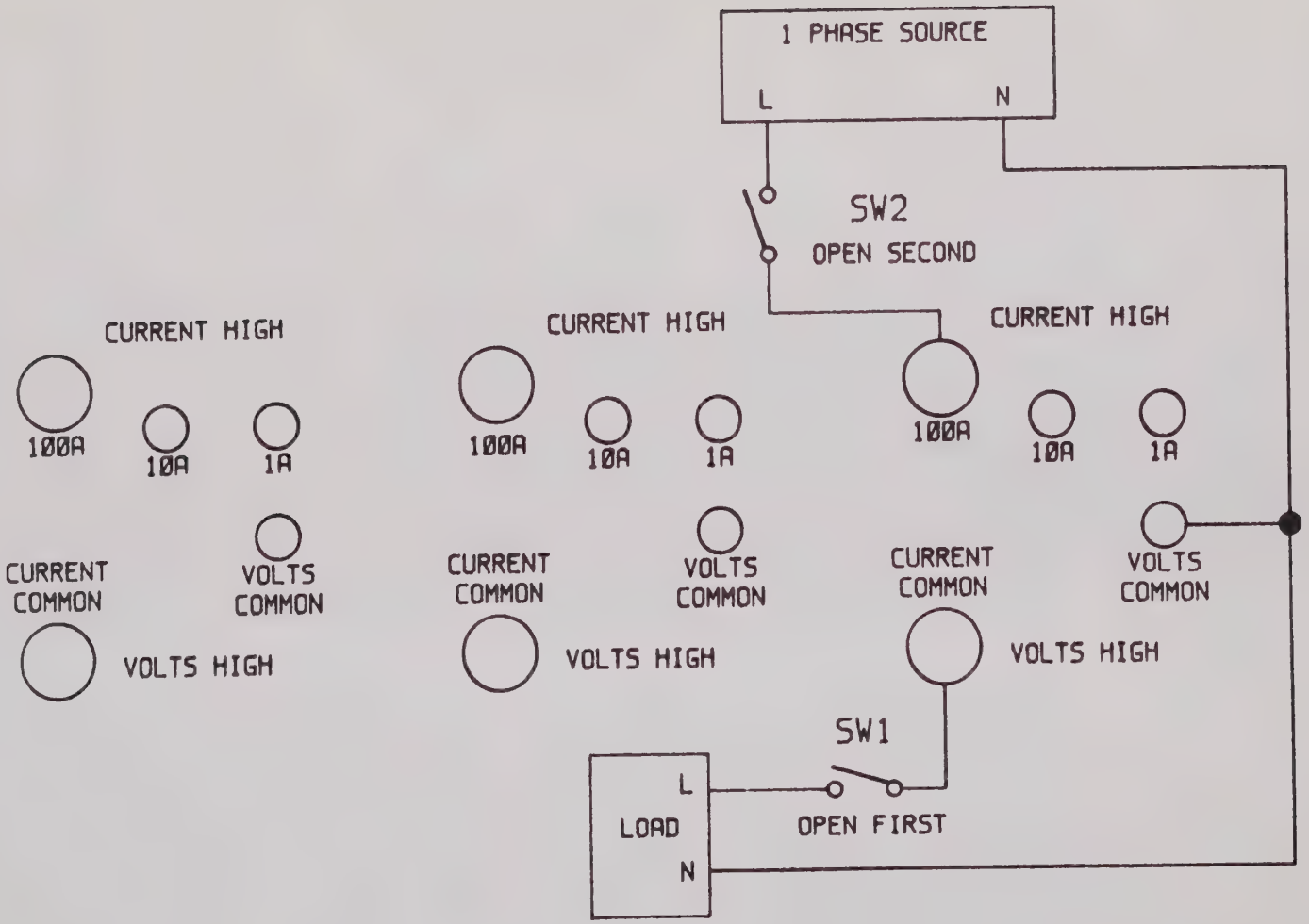


FIGURE 1 SINGLE PHASE INDUCTIVE LOAD PROTECTION METHOD 1

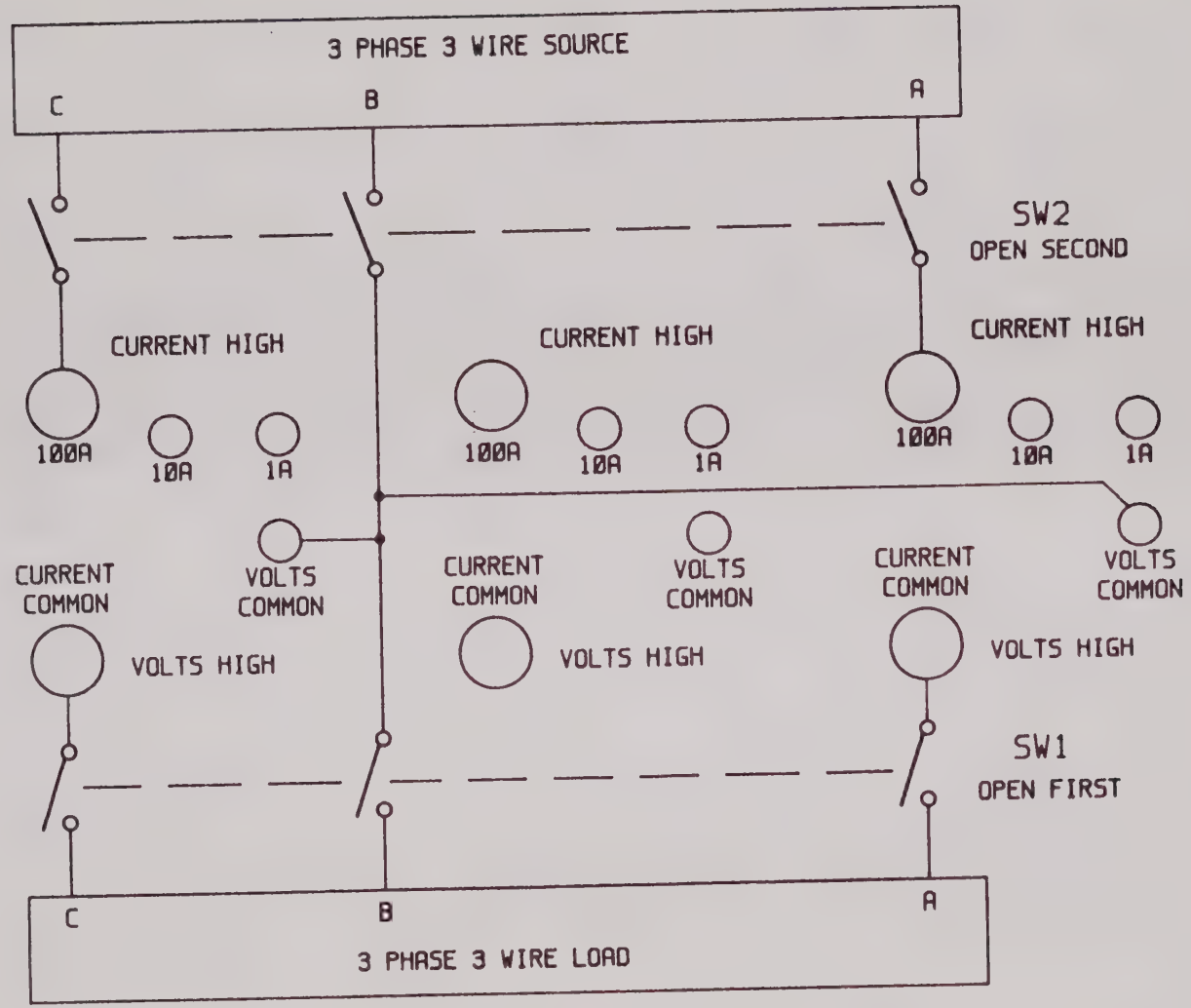


FIGURE 2 3 PHASE 3 WIRE INDUCTIVE LOAD PROTECTION METHOD 1

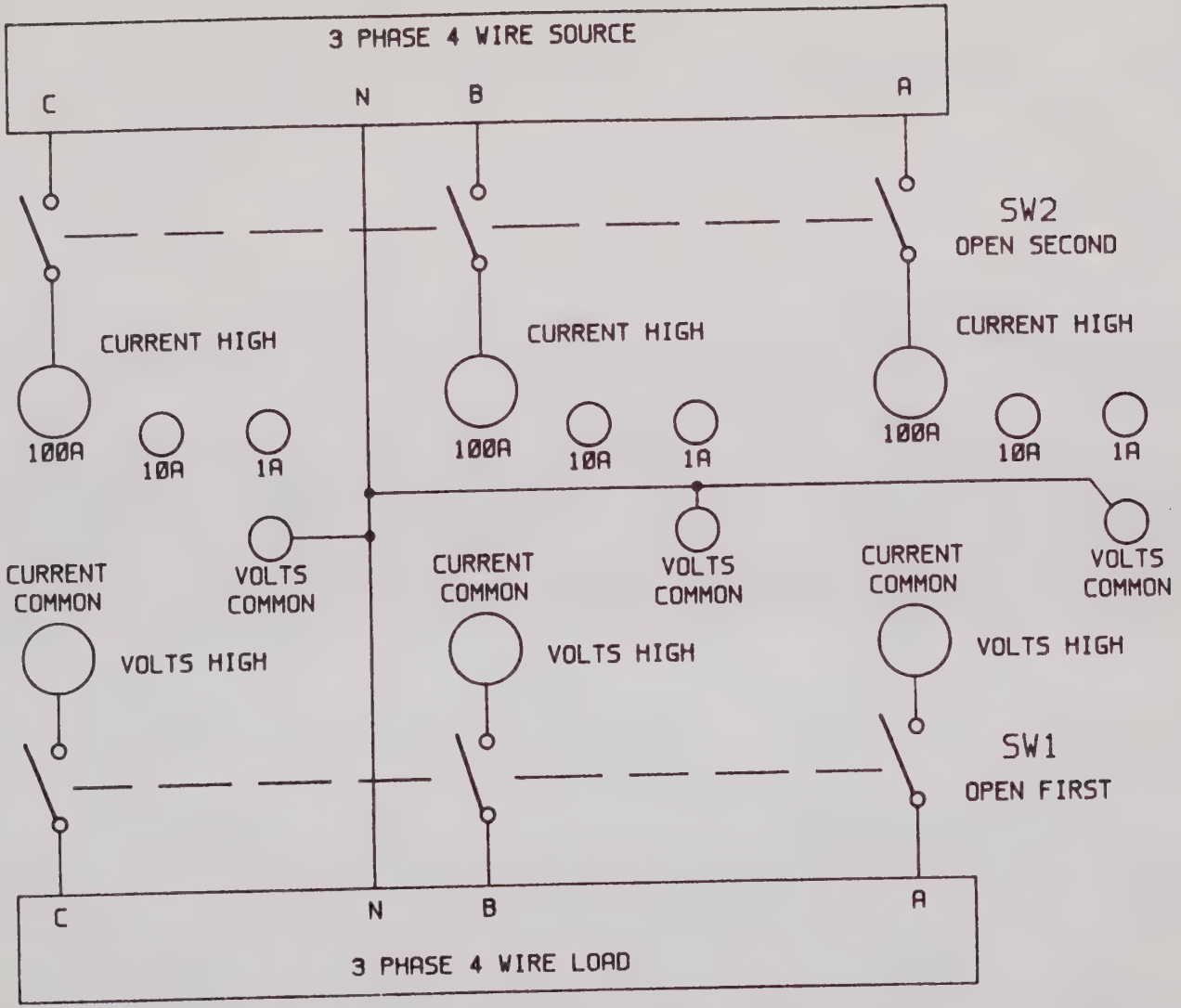


FIGURE 3 3 PHASE 4 WIRE INDUCTIVE LOAD PROTECTION METHOD 1

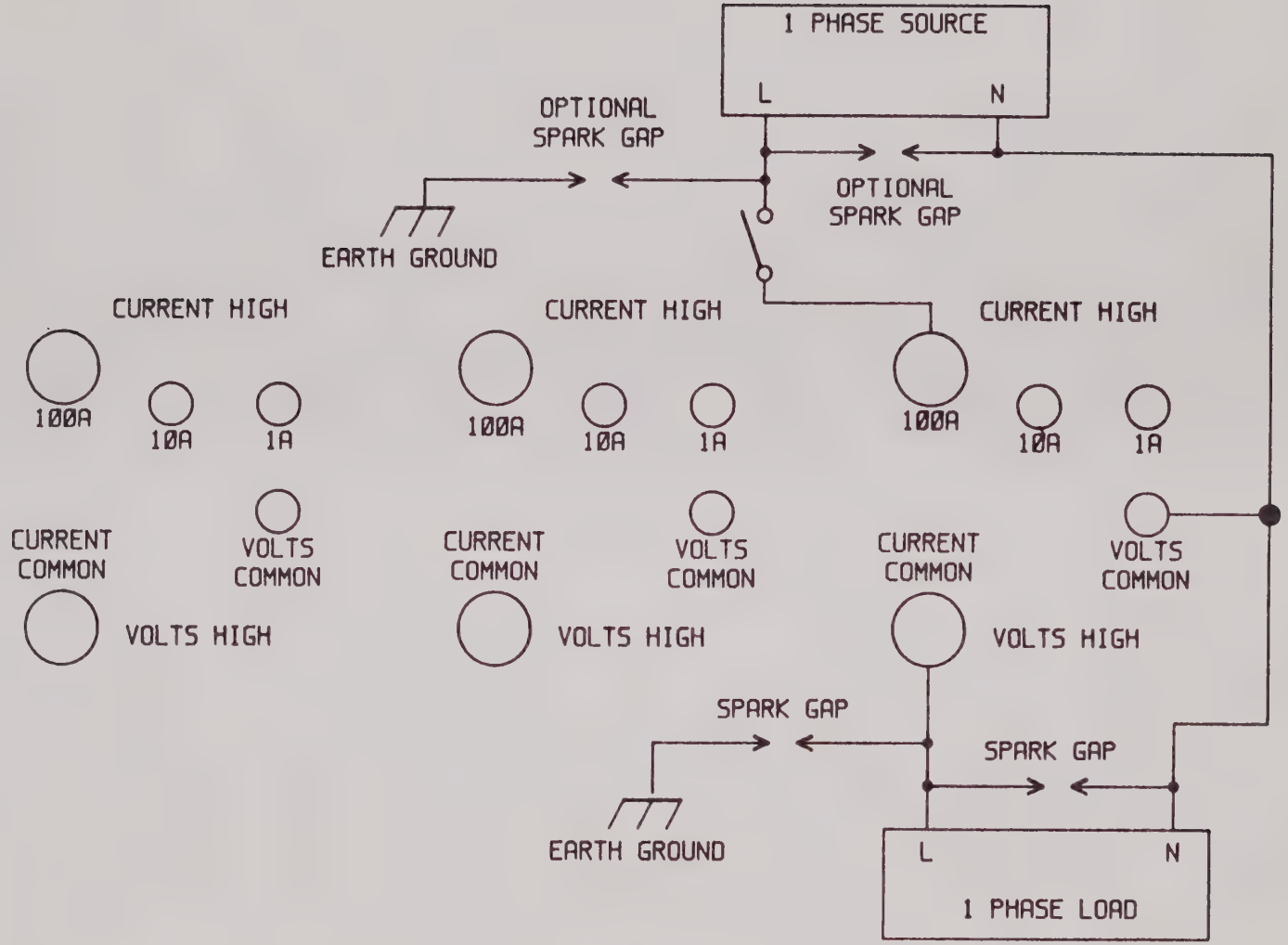


FIGURE 4 SINGLE PHASE INDUCTIVE LOAD PROTECTION METHOD 2

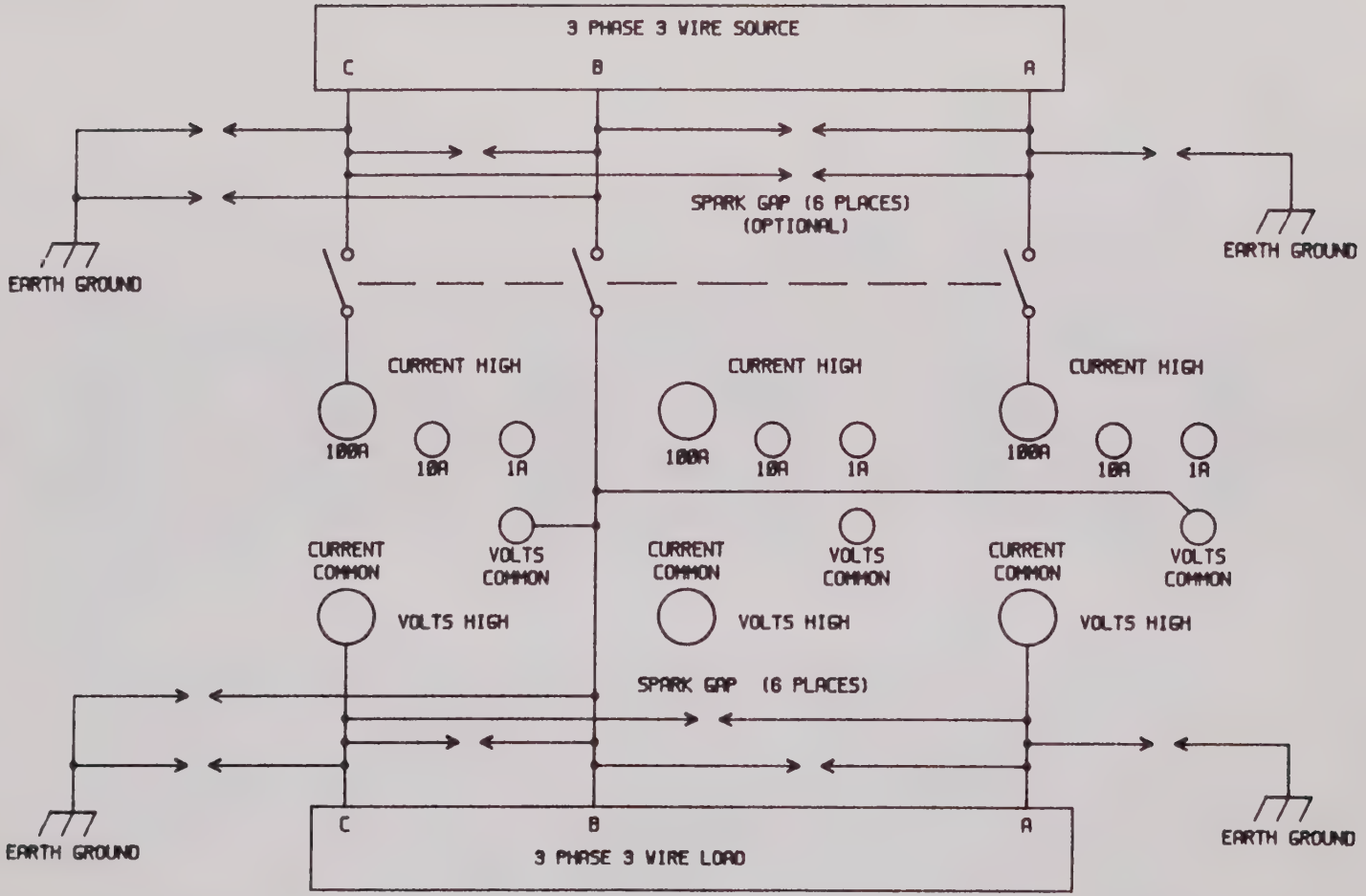


FIGURE 5 3 PHASE 3 WIRE INDUCTIVE LOAD PROTECTION METHOD 2

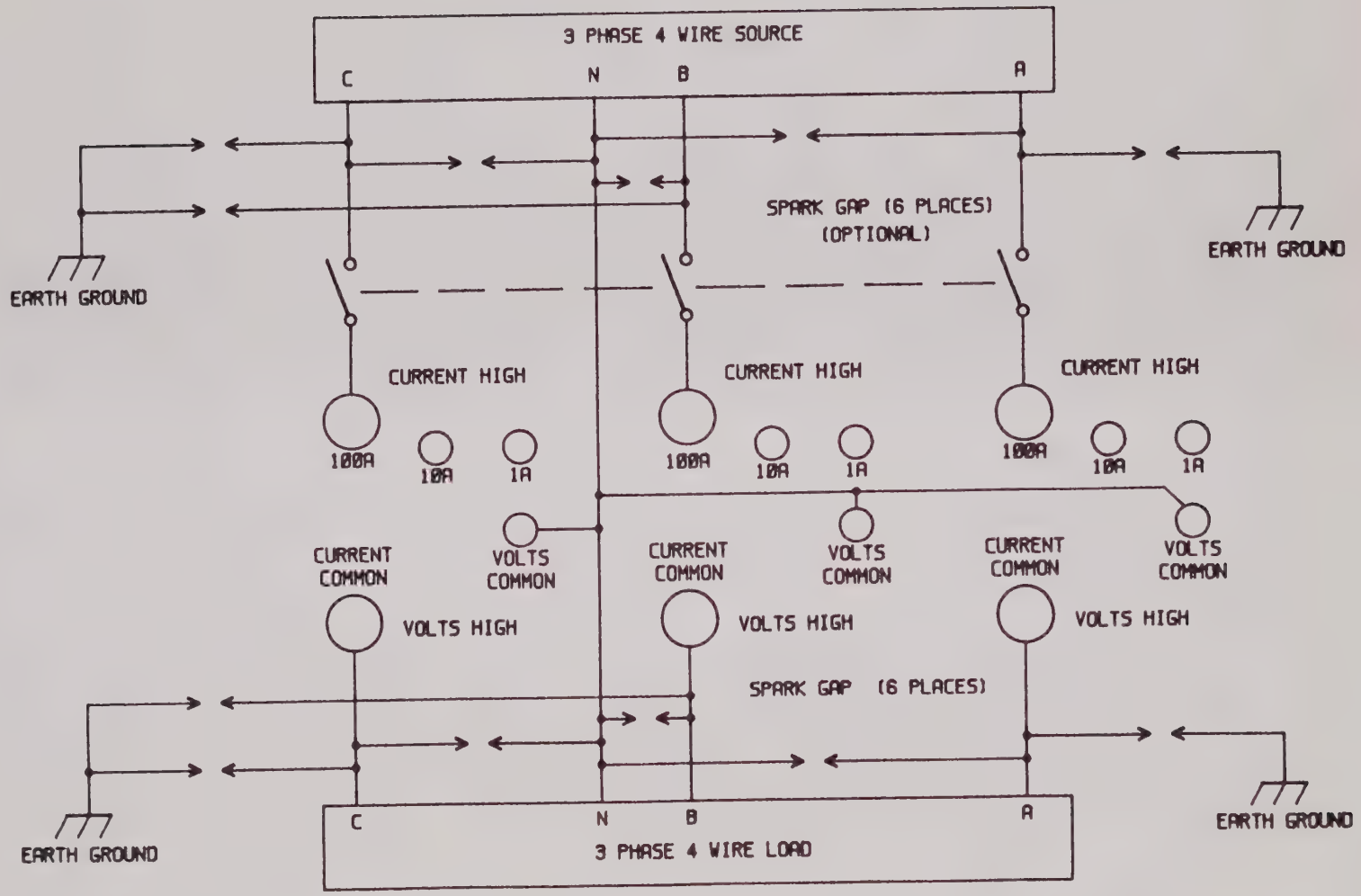


FIGURE 6 3 PHASE 4 WIRE INDUCTIVE LOAD PROTECTION METHOD 2

APPLICATION NOTE AN102
USING CURRENT AND POTENTIAL TRANSFORMERS WITH VALHALLA SCIENTIFIC DIGITAL POWER ANALYZERS

102-1. General

Current and potential transformers (CT's and PT's) may be used with any Valhalla Digital Power Analyzer to increase its measurement range. Clamp-on CT's may also be used to simplify power analyzer connections.

102-2. Current Transformers

Current transformers (CT's) are used to extend the current measurement capabilities of Valhalla digital power analyzers. CT's are available in many ratios, maximum current ratings and isolation voltages.

There are two styles of CT's available, fixed and clamp-on. Fixed CT's are generally used for permanent test set-ups. The conductor being measured must be disconnected, passed through the center of the CT, and reconnected. Clamp-on CT's are easier to use because they are just clamped around the conductor. The conductor need not be disconnected when using a clamp-on CT.

CT's are also used for isolating the power analyzer from high voltage systems. Many high voltage systems operate at current levels directly measurable by the power analyzer, but with voltages beyond the power analyzer limits. The isolation voltage rating should be at least 1½ times the peak input voltage.

The ratio accuracy of CT's is usually about 2%. This is quite a bit wider than the accuracy of a digital power analyzer. The easiest way to improve this accuracy is to measure the actual ratio and use this value when correcting measurements. CT's are low frequency devices, typically 50-400Hz. At high frequencies their phase shift will cause the power measurement to be in error.

CAUTION!

When using CT's, never open-circuit their secondaries while power is applied!!

The CT will act like a step-up transformer and may produce lethal voltages which can damage the operator and/or the power analyzer.

Figure 1 illustrates the basic method of connecting a CT to a digital power analyzer. Other methods are shown in Section 6.

102-3. Potential Transformers

Potential transformers (PT's) are used to extend the voltage measurement capabilities of Valhalla digital power analyzers. PT's are available in many ratios, maximum voltage ratings and isolation voltages.

PT's can be used to isolate the digital power analyzer from high voltage systems. Some high voltage systems operate at voltage levels directly measurable by the power analyzer but at common mode voltages beyond the power analyzer's limits. The isolation voltage rating should be at least 1½ times the common mode voltage or peak input voltage.

The ratio accuracy of PT's is usually about 2%. This is quite a bit wider than the accuracy of a digital power analyzer. The easiest way to improve the accuracy is to measure the actual ratio and use this value when correcting measurements. PT's are low frequency devices, typically 50-400Hz. At high frequencies, their phase shift will cause the power measurement to be in error. Figure 2 illustrates the method of connecting a PT to a digital power analyzer. Other methods are shown in Section 6.

102-4. Using Both CT's and PT's

Many applications using PT's will use CT's as well. In this case, the power measurement must be multiplied by both the CT and PT ratios. Figure 3 illustrates a method of connecting a CT and PT to a digital power analyzer. Section 6 contains other variations on this method.

102-5. Poly-Phase Systems

When measuring poly-phase systems, multiple CT's and/or PT's are required. When calculating total power, the individual phase powers should be scaled by the CT/PT ratios and then summed as shown below:

Total Power =

$$(W_a \times PT_a \times CT_a) + (W_b \times PT_b \times CT_b) + (W_c \times PT_c \times CT_c) + \ldots + (W_n \times PT_n \times CT_n)$$

Where:

W_n = Phase n watts
PT_n = Phase n PT ratio
CT_n = Phase n CT ratio

☞ The 2330A incorporates a feature that will perform all of these calculations automatically. Please refer to section 6-8-6 for details.

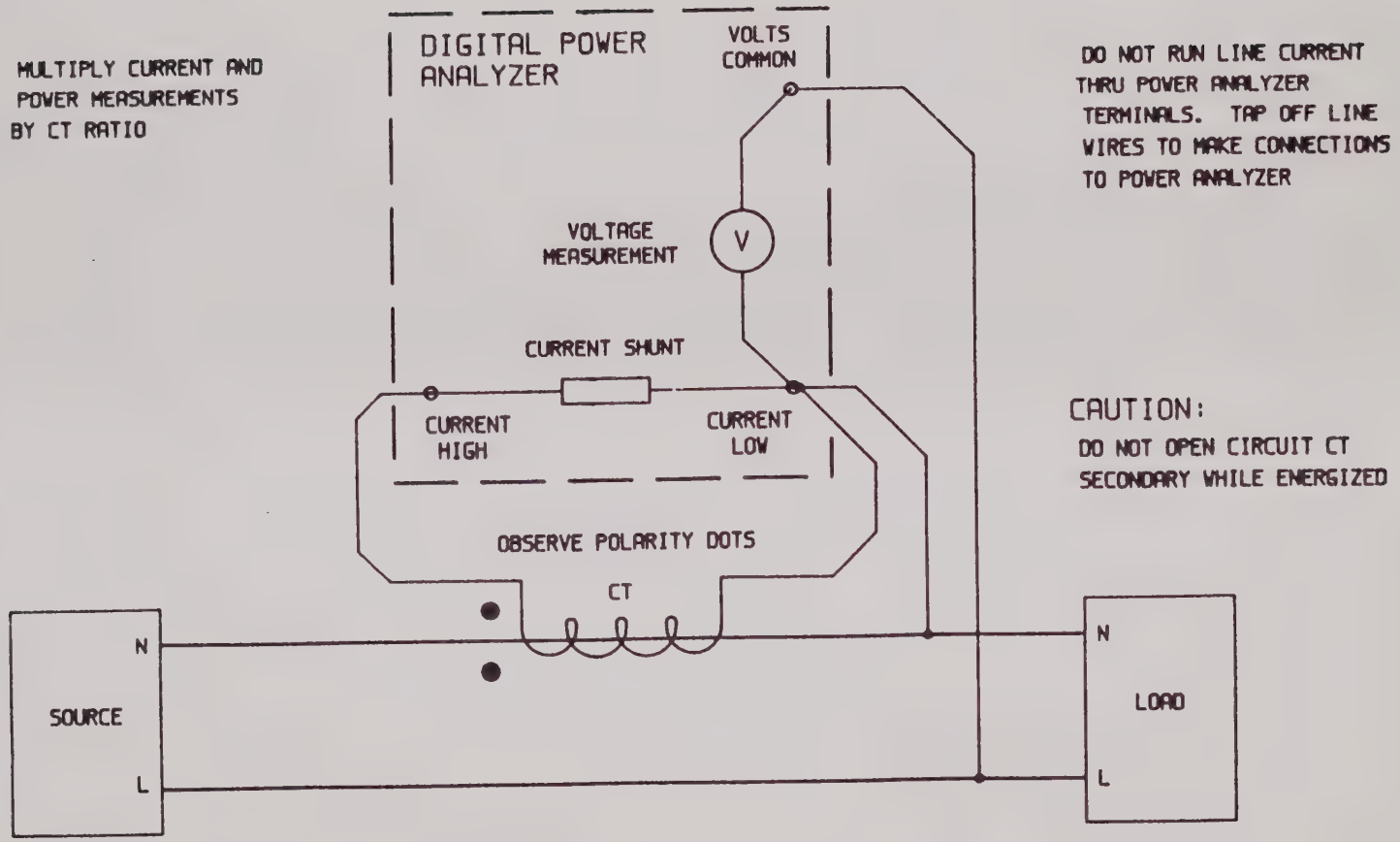


FIGURE 1 CURRENT TRANSFORMER CONNECTIONS

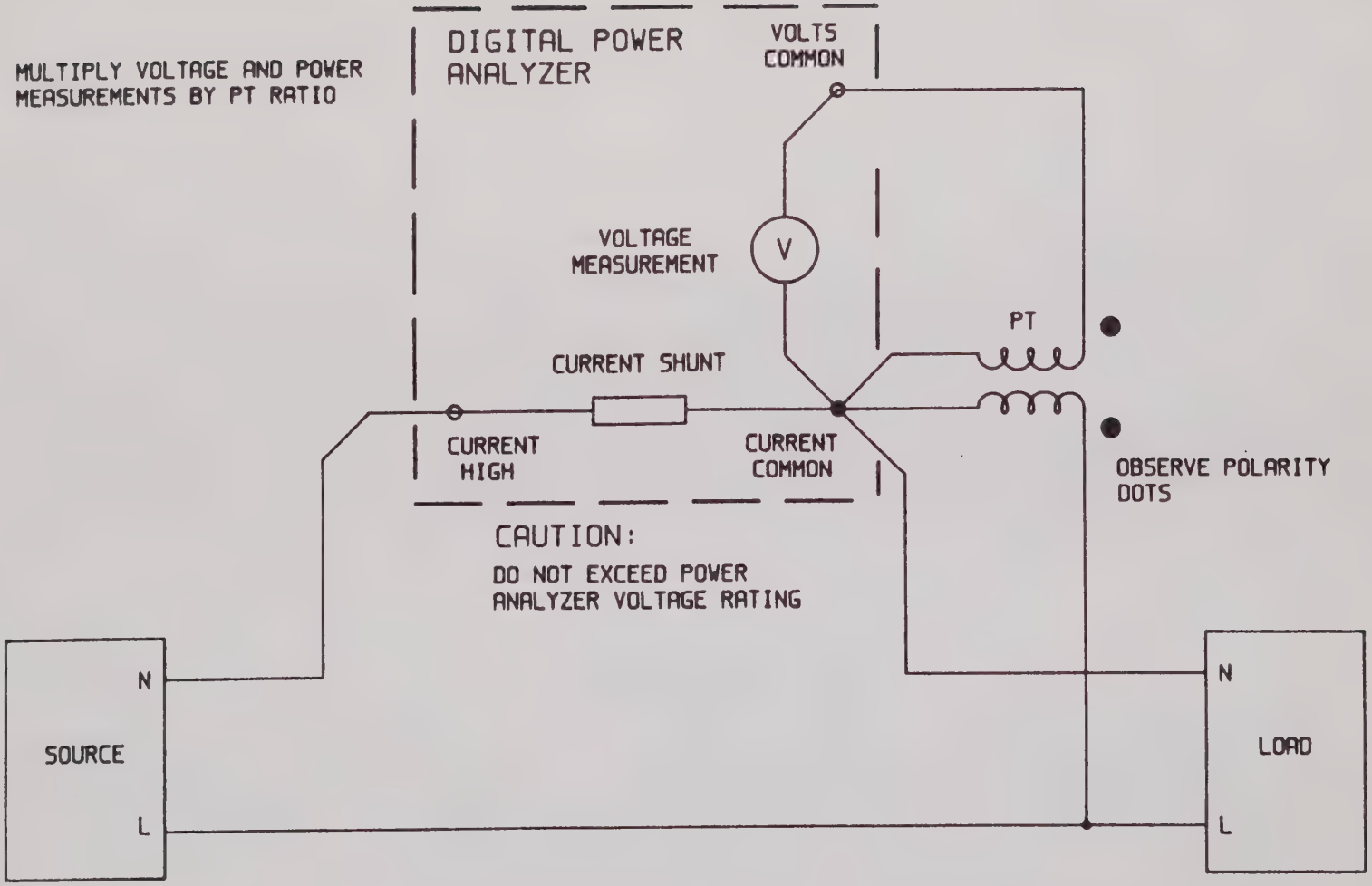


FIGURE 2 POTENTIAL TRANSFORMER CONNECTIONS

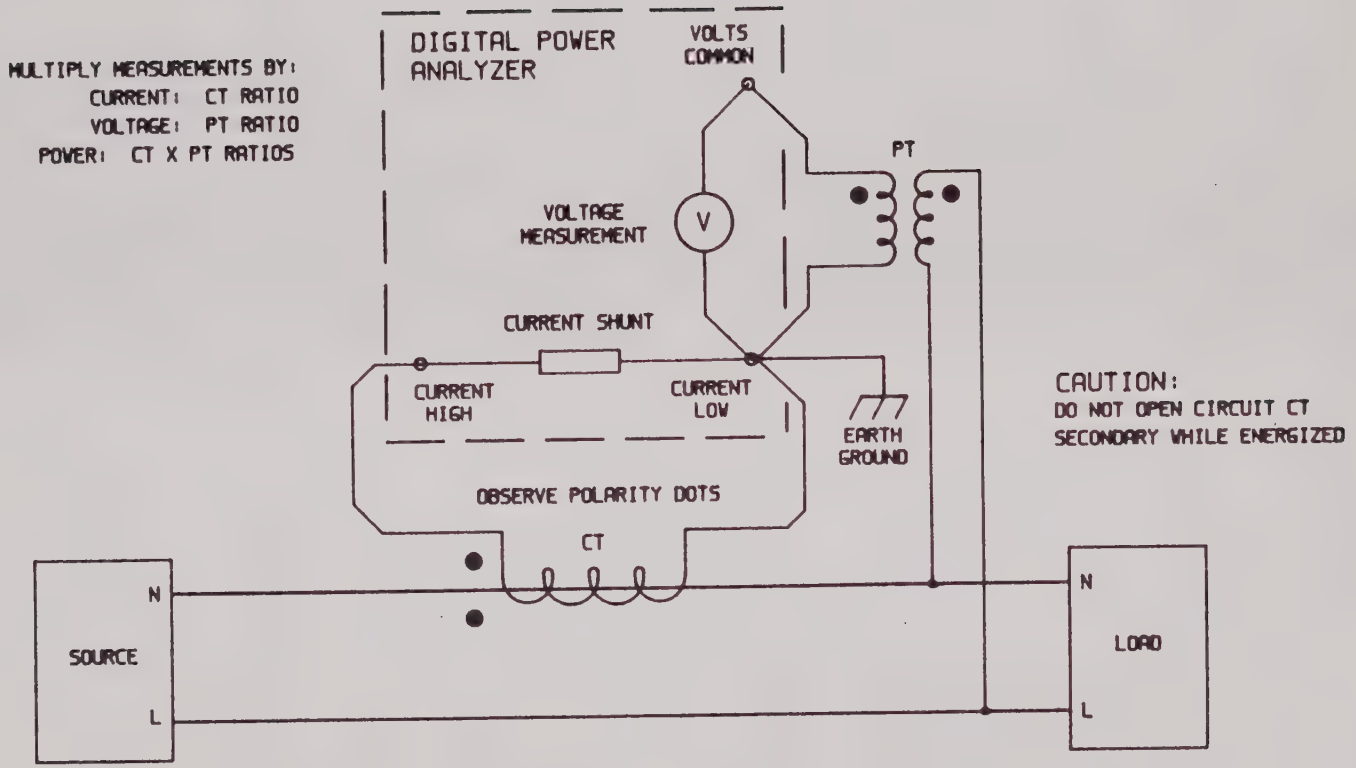


FIGURE 3 CURRENT TRANSFORMER / POTENTIAL TRANSFORMER CONNECTIONS

APPLICATION NOTE AN103
SOURCE POWER MEASUREMENTS WITH THE 2330A

103-1. General

The 2330A is ideally suited for measuring the power supplied by a source, e.g. a battery, generator or alternator. The standard method of connecting the 2330A is for measuring the power drawn by a load rather than the power supplied by a source. The difference in these measurements can be quite significant. A look at how the 2330A measures power will aid the user in measuring source power.

103-2. Power Measurement

The 2330A determines power by measuring the voltage across the load, the current through the load and the phase difference between them. The 2330A multiplies these measurements to obtain power.

Figure 1 details the standard load power connections. Note that the power measured is *not* the power supplied by the source. Several watts may be dissipated by the current shunt which is not measured by the 2330A.

Figure 2 details the connections for measuring source power. The 2330A measures the total of the power dissipated by the load and the current shunt. The only other source of inaccuracy is the power dissipated in the connecting leads. Figure 3 details these error sources. The effect of lead resistance can be reduced by connecting the 2330A as shown in Figure 4 and by using heavy gauge wires and ensuring tight connections.

103-3. Summary

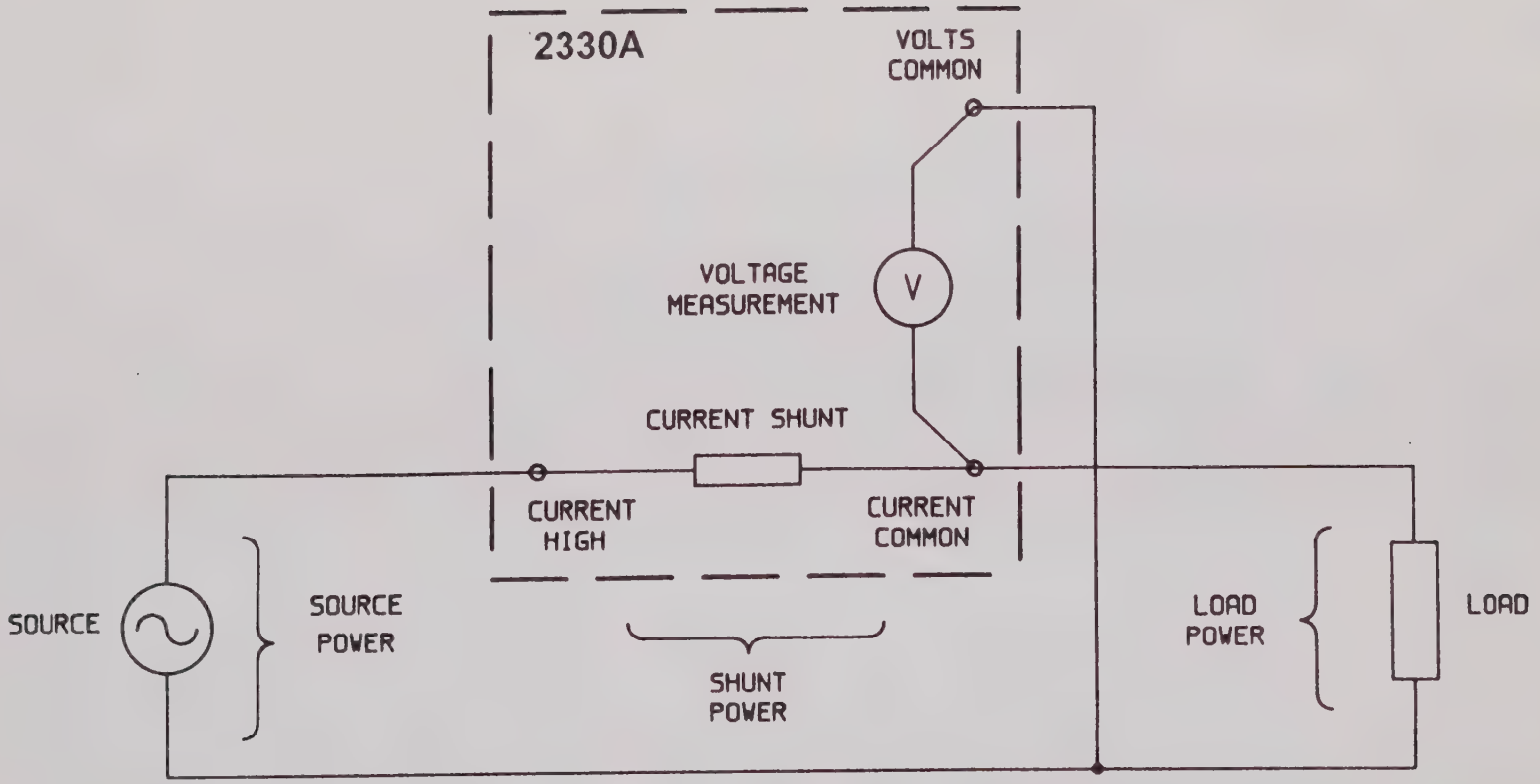
The preceding paragraph described the techniques for measuring the power supplied by a source. The examples shown used single-phase connections for clarity. The same techniques can be used for poly-phase systems as well. Three-phase variations on this drawing may be found in Section 6. When making source power measurements, the power measurement should be multiplied by minus one (-1) to obtain the correct watts polarity. The following checklist will aid the user in obtaining accurate source power measurements:

1. Connect the 2330A to the source and load as shown in Figure 4.

2. Use short, heavy gauge wire between the source and the current common terminal.

3. Tighten all connections.

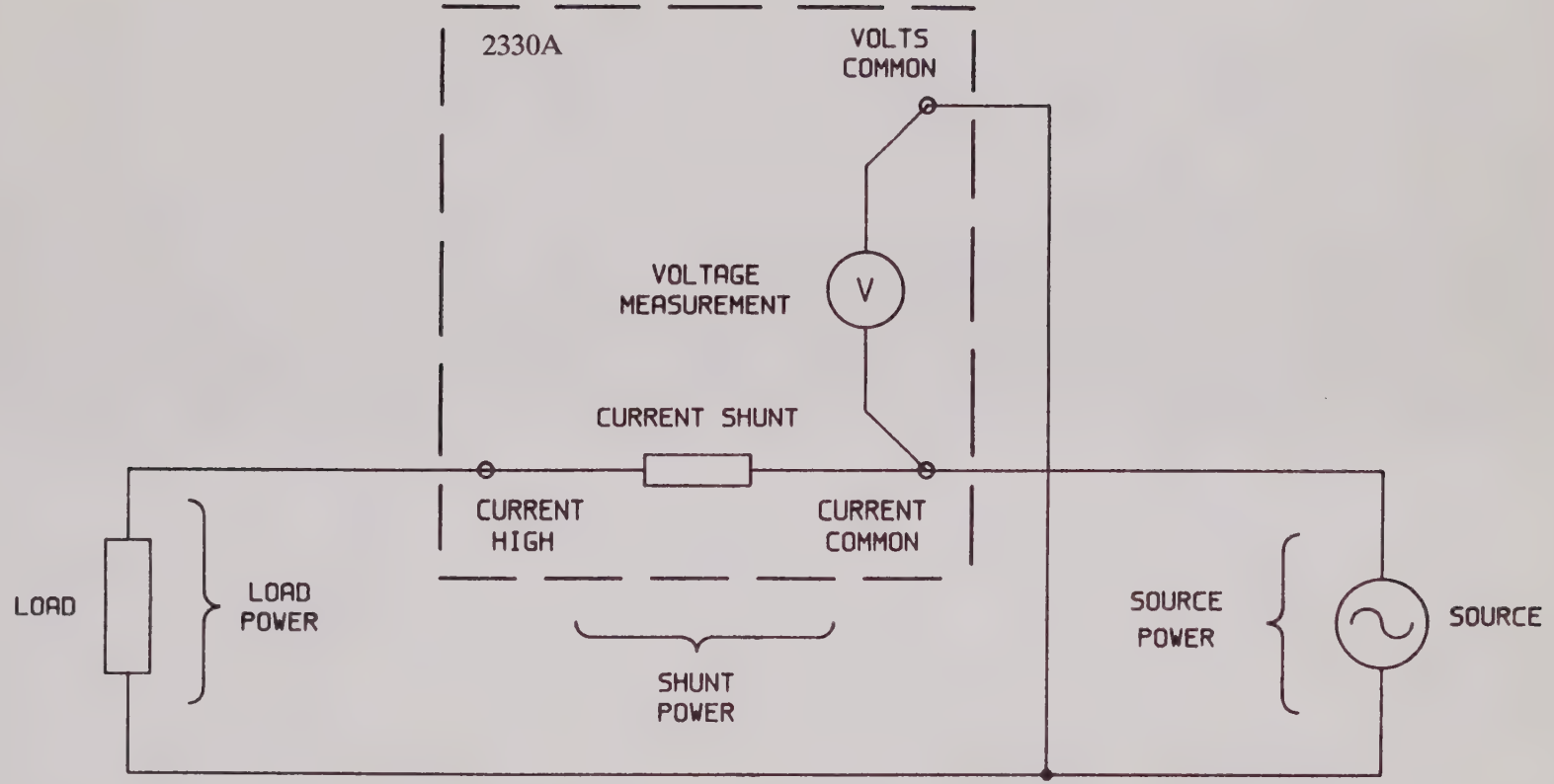
4. Multiply the power reading by minus one (-1).



SOURCE POWER = LOAD POWER + SHUNT POWER

2330A MEASURES POWER IN LOAD ONLY

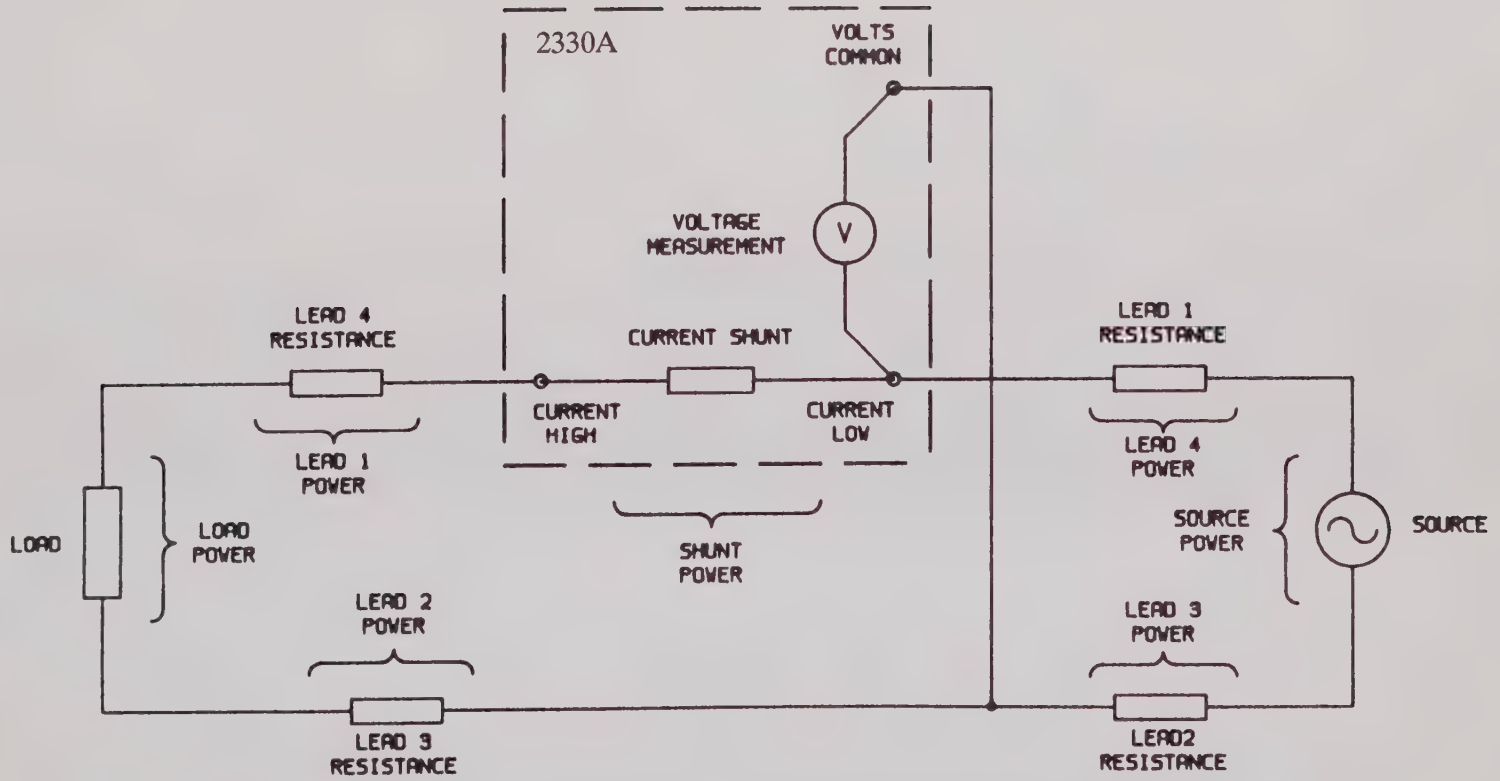
FIGURE 1 LOAD POWER CONNECTIONS



SOURCE POWER = LOAD POWER + SHUNT POWER

2330A MEASURES POWER SUPPLIED BY SOURCE

FIGURE 2 SOURCE POWER CONNECTIONS

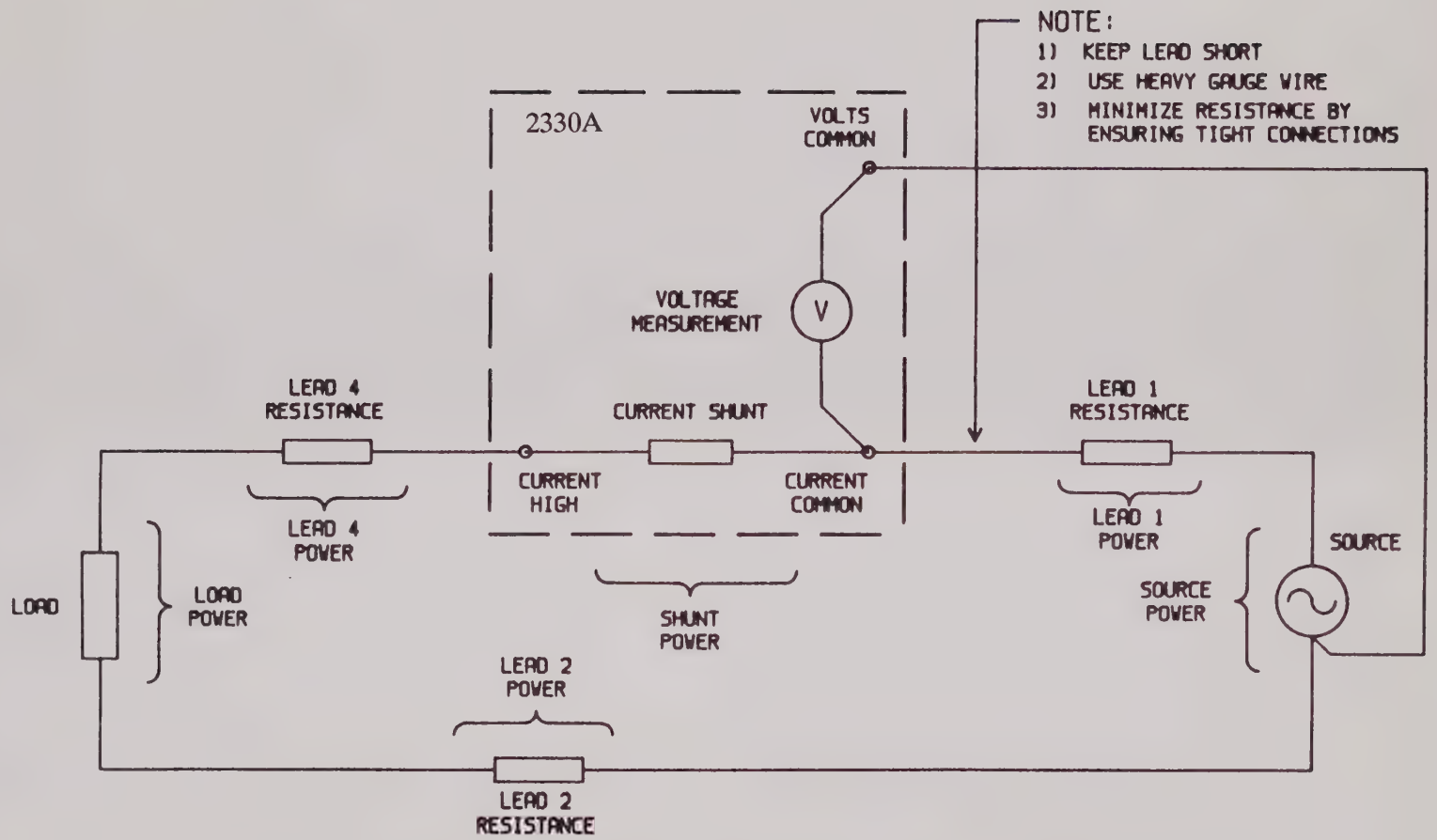


SOURCE POWER = LOAD POWER + SHUNT POWER + LEAD 1 - 4 POWERS

2330A MEASURES LOAD POWER + SHUNT POWER + LEAD 3 POWER + LEAD 4 POWER

MEASUREMENT ERROR = LEAD 1 POWER + LEAD 2 POWER

FIGURE 3 LEAD RESISTANCE ERROR SOURCES



SOURCE POWER = LOAD POWER + SHUNT POWER + LEAD 1 - 4 POWERS

2330A MEASURES LOAD POWER + SHUNT POWER + LEAD 2 - 4 POWER

MEASUREMENT ERROR = LEAD 1 POWER

FIGURE 4 MINIMIZING ERROR SOURCES

APPLICATION NOTE AN104
MEASURING PHASE CURRENTS IN 3-WIRE SYSTEMS WITH THE 2330A

104-1. General

The 2330A is ideally suited for measuring the power in a 3-phase 3-wire connected load. Some test procedures require that the individual phase currents be measured and recorded. The standard 3-phase 3-wire connections allow for displaying the phase A and phase C currents directly. The phase B current is usually measured with an external ammeter. The 2330A can easily be reconnected to measure the phase B current as well.

104-2. Connections

The standard 3-phase 3-wire connections are shown in Figure 1. In it, the 2330A uses the two wattmeter method of measuring 3-phase 3-wire power. The channel B wattmeter is not used. The channel B wattmeter can easily be connected to measure the phase B current as shown in Figure 2. The phase currents for each channel are displayed in the channel rows. The total power is displayed in the summing row.

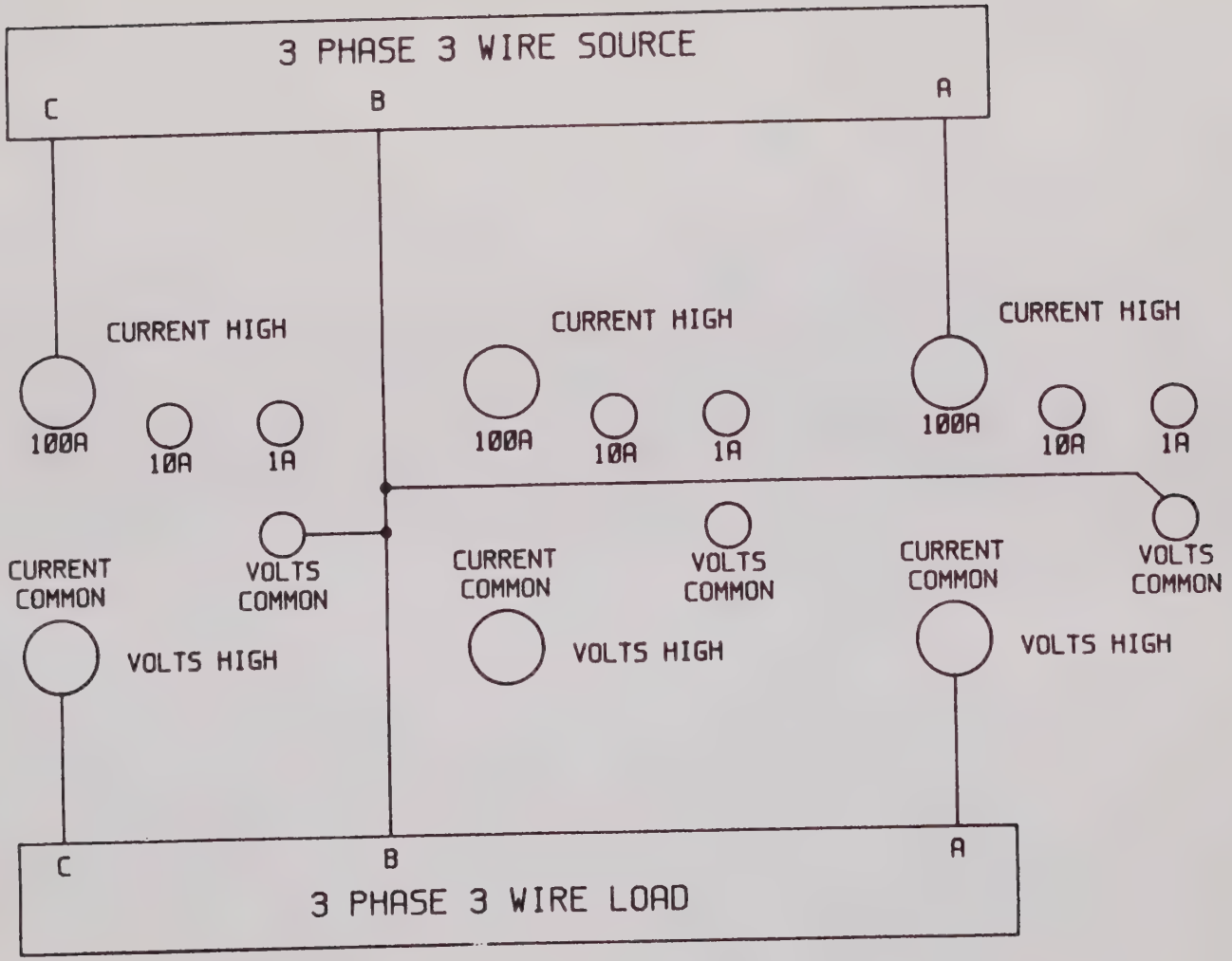


FIGURE 1 3 PHASE 3 WIRE STANDARD CONNECTIONS

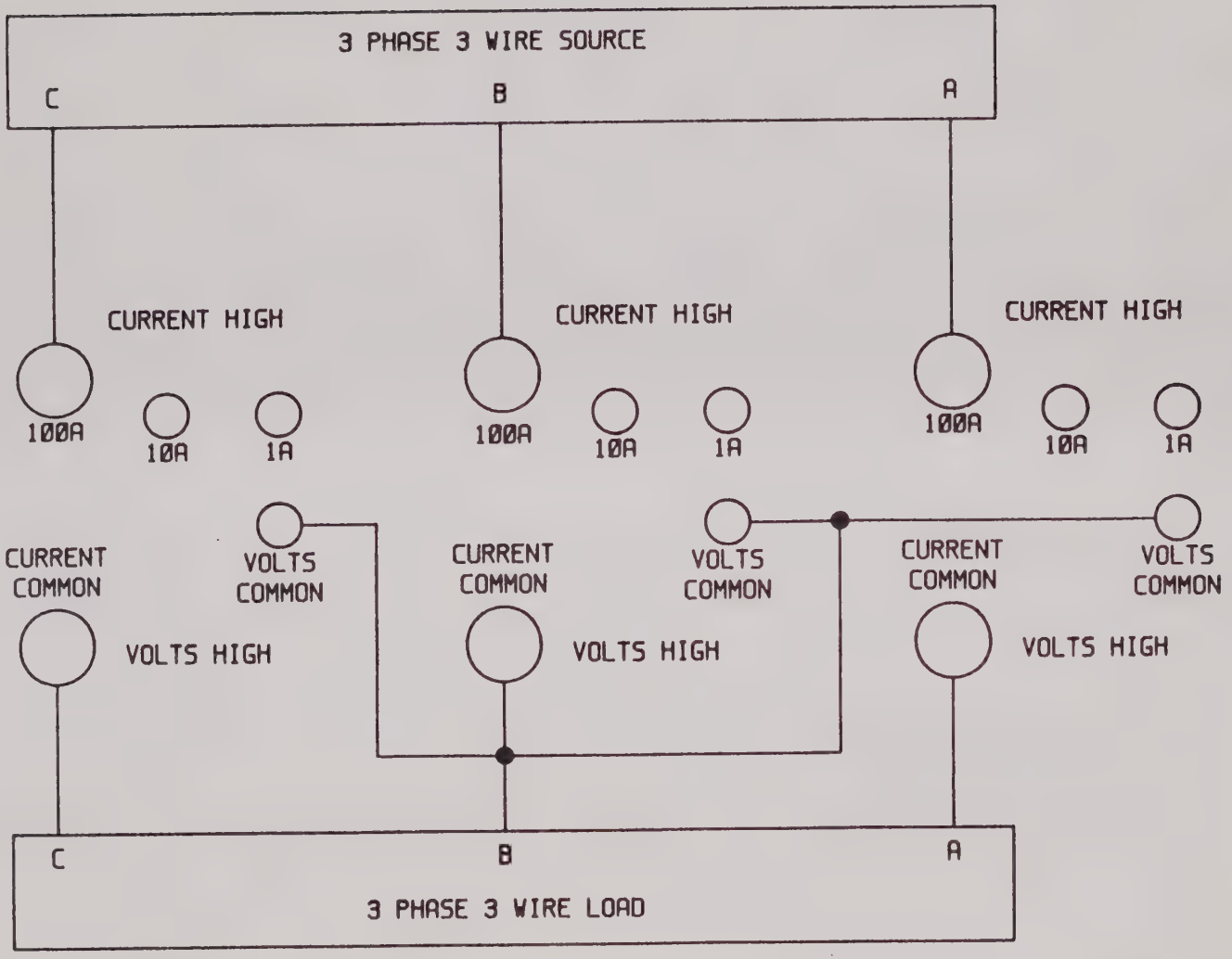


FIGURE 2 ALTERNATE 3 PHASE 3 WIRE CONNECTIONS

APPLICATION NOTE AN105
MEASURING TRANSFORMER LOSS
WITH THE 2330A

105-1. General

The 2330A is ideally suited for measuring the loss of single-phase transformers. The following paragraph describes the connections required to display transformer loss on the 2330A.

105-2. Connections

Figure 1 details the connections to the 2330A. Channel A of the 2330A is connected to measure the input power drawn by the transformer. Channel C measures the power sourced by the transformer secondary. When the 2330A is connected for source power measurement, the power display has a negative polarity.

The 3-wire-Delta configuration of the 2330A should be selected to sum the measurements of channels A and C. The result in the summing row is the difference between the power drawn by the transformer and the power sourced by the transformer. This difference is the "loss" or the amount of power dissipated by the transformer.

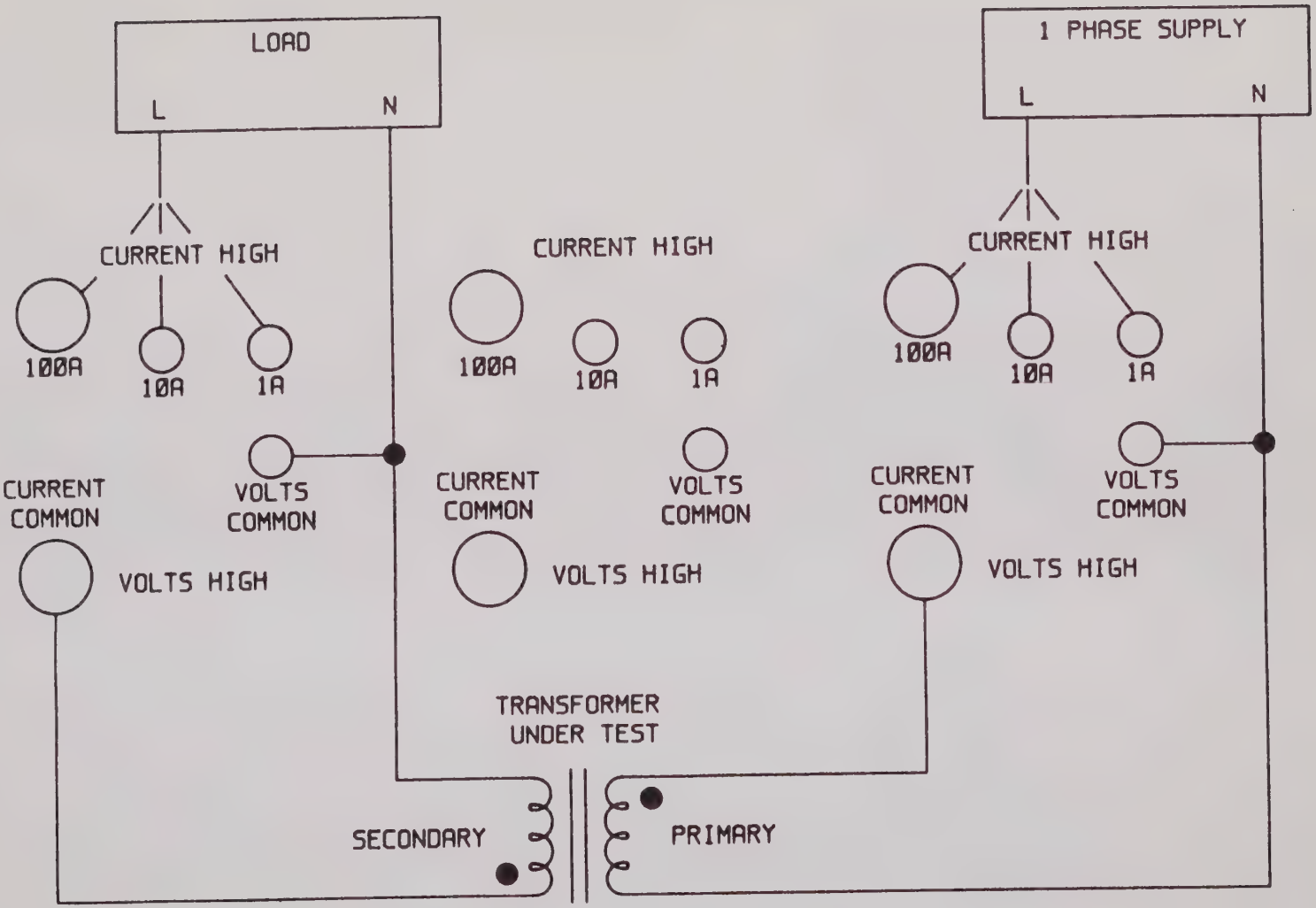


FIGURE 1 TRANSFORMER LOSS CONNECTIONS

APPLICATION NOTE AN106
MEASURING POWER FACTOR AND REACTIVE VOLT-AMPERES WITH VALHALLA SCIENTIFIC DIGITAL POWER ANALYZERS

106-1. VA's, Watts, VAR's and PF

The relationships between VA's, Watts, VAR's and PF can best be described in a graphical manner. Figure 1 illustrates these relationships. VA's are calculated by multiplying the true RMS voltage and true RMS current measurements of the digital power analyzer. Power factor is the cosine of the angle between VA's and Watts and can be calculated using basic trigonometry. Reactive power, VAR's, is calculated from VA's and Watts using Pythagorean's theorem.

106-3. PF, Leading or Lagging?

The terms leading and lagging power factor refer to the relative phase shift between the current and voltage waveforms. The current leads the voltage in a capacitive load while the current lags the voltage in an inductive load. The 2330A illuminates a red indicator labeled **AMPS LAGGING** on the front panel whenever the current measured on any channel is lagging the voltage.

☞ The following text may be used as a mathematical proof of the method by which the 2330A determines VA, VAR, PF, and WATTS.

106-4. Single-Phase Systems

Determining VA's, VAR's and PF in single-phase systems is straightforward. Connect the digital power analyzer to the load and record the voltage, current and power. Calculate VA's, VAR's and PF as shown in Figure 1.

106-5. Poly-Phase Systems

Determining VA's, VAR's and PF in poly-phase systems is a little more involved than for single-phase systems. The discussion below is for three-phase systems, however the same ideas can be expanded for any poly-phase system.

To determine three-phase VA's and PF, the individual phase VAR's must first be calculated. Referring to Figure 1, it can be seen that VA's do not add up unless the individual power factors are identical. VAR's and Watts can be algebraically summed to obtain three-phase Watts and VAR's. Three-phase VA's and PF are then calculated from three-phase Watts and VAR's.

106-5-1. 3ϕ 4-Wire-Y VA, VAR and PF

To determine VA, VAR and PF for 3ϕ 4-wire-Y connected loads, the following procedure is recommended. Refer to Figure 1:

1) Connect the 2330A to the load as described in Section 6.
2) Measure and record the voltage, current, and power for each phase.
3) Calculate ϕA VA's and VAR's.
4) Calculate ϕB VA's and VAR's.
5) Calculate ϕC VA's and VAR's.
6) Add ϕA, ϕB and ϕC VAR's to obtain 3-phase VAR's.

7) Add ϕA, ϕB and ϕC watts to obtain 3-phase watts.
8) Calculate 3-phase VA's from 3-phase VAR's and watts.
9) Calculate 3-phase PF from 3-phase VA's and watts.

When calculating 3-phase VAR's, it is safe to assume that the individual phase PF's are all lagging if the load has a transformer or motor.

106-5-2. 3ϕ 3-Wire-Delta VA, VAR and PF

To determine VA, VAR and PF in 3ϕ 3-wire-Delta connected loads, the following procedure is recommended. Refer to Figure 1.

1) Connect the 2330A to the load as described in Section 6.
2) Measure and record the voltage, current and power for ϕA and ϕC.
3) Calculate ϕA VA's and VAR's.
4) Calculate ϕC VA's and VAR's.
5) Add ϕA and ϕC VAR's to obtain 3-phase VAR's.
6) Add ϕA and ϕC watts to obtain 3-phase watts.
7) Calculate 3-phase VA's from 3-phase VAR's and watts.
8) Calculate 3-phase PF from 3-phase VA's and watts.

When calculating 3-phase VAR's it is safe to assume that the individual phase power factors are all lagging if the load has a transformer or motor.

106-6. PF and VAR Accuracies

The accuracies of the PF and VAR calculations are the sums of the accuracies of the voltage, current and power measurements. For the 2330A, the accuracies are as shown below:

SINGLE PHASE

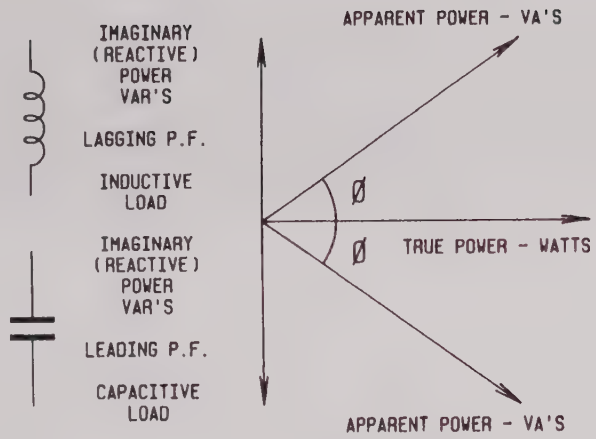
±0.1% Vrng ±0.25% Arng ±0.25% Wrng

3-PHASE 3-WIRE

±0.2% Vrng ±0.5% Arng ±0.5% Wrng

3-PHASE 4-WIRE

±0.3% Vrng ±0.75% Arng ±0.75% Wrng



$$PF = \cos \emptyset = \frac{W}{VA}, \text{ LAGGING}$$

$$PF = \cos \emptyset = \frac{W}{VA}, \text{ LEADING}$$

$$VA'S = \text{TRMS VOLTS} \times \text{TRMS AMPS}$$

$$VAR'S = \sqrt{VA'S^2 - W'S^2}$$

$$VA'S = \sqrt{VAR'S^2 + W'S^2}$$

$$W'S = \sqrt{VA'S^2 - VAR'S^2}$$

FIGURE 1 WATTS, VA'S, VAR,S AND PF

APPLICATION NOTE AN107
MINIMIZING ERROR SOURCES IN THREE-WIRE CONNECTED DIGITAL POWER ANALYZERS

107-1. General

This application note describes the sources of measurement error in three-wire type digital power analyzers. Methods for reducing these error sources are also discussed.

107-2. 3-Wire Digital Power Analyzers

The term "3-wire digital power analyzer" refers to the number of terminals the analyzer uses to connect to the load under test. Referring to Figure 1, the power analyzer measures the current flowing through the current shunt and the voltage between the current shunt and voltage common terminal. The voltage measurement and current measurement sections of the analyzer share a common terminal.

107-3. Error Sources

Measurement errors arise in three-wire type digital power analyzers due to connecting lead resistances. A power analyzer hook-up showing error sources is shown in Figure 2. The contact and lead resistances are combined and shown as "R LEAD x", with the x denoting the individual lead. Lead resistances 1 and 2 do not contribute any error other than lowering the effective source voltage. Lead resistances 3 and 4 are sources of error. The power analyzer measures the voltage drop across the load plus the lead resistances. The power measurement will be in error by the sum of the lead (I^2R) powers.

107-4. Error Reduction

The errors caused by the lead resistances can be reduced by a factor of 2 by simply reconnecting the voltage common terminal of the power analyzer as shown in Figure 3. The effect of "R LEAD 3" is eliminated. The effect of "R LEAD 4" can be reduced by using a short heavy gauge wire and ensuring tight connections. In applications where it is impractical to shorten lead 4, an alternate technique is discussed below.

A measurement is first made using the connections of Figure 3. The connections are then changed to those of Figure 4. This connection measures the power in lead 4. This power is then subtracted from the first measurement yielding an accurate representation of the power in the load only.

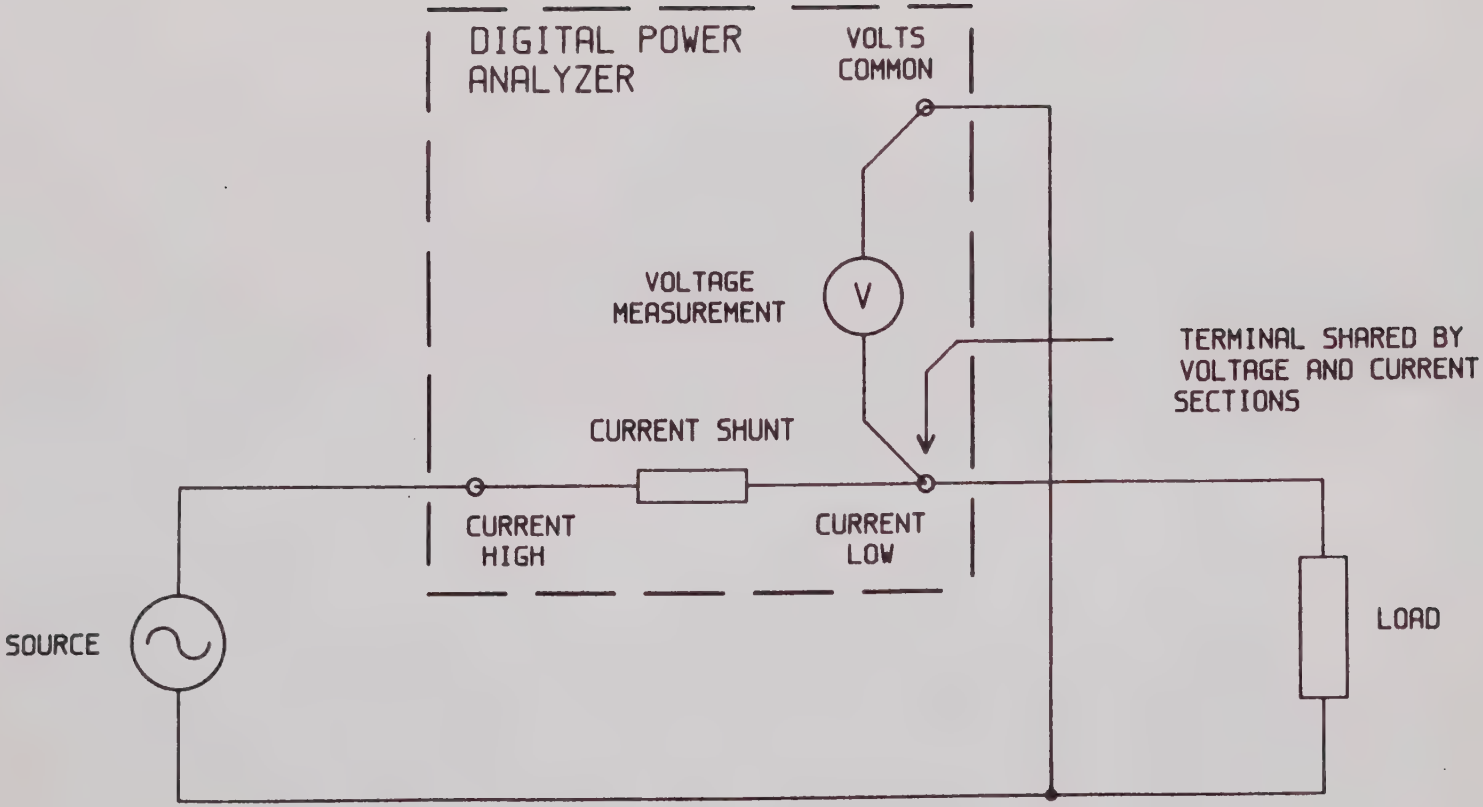


FIGURE 1 THREE WIRE TYPE DIGITAL POWER ANALYZER

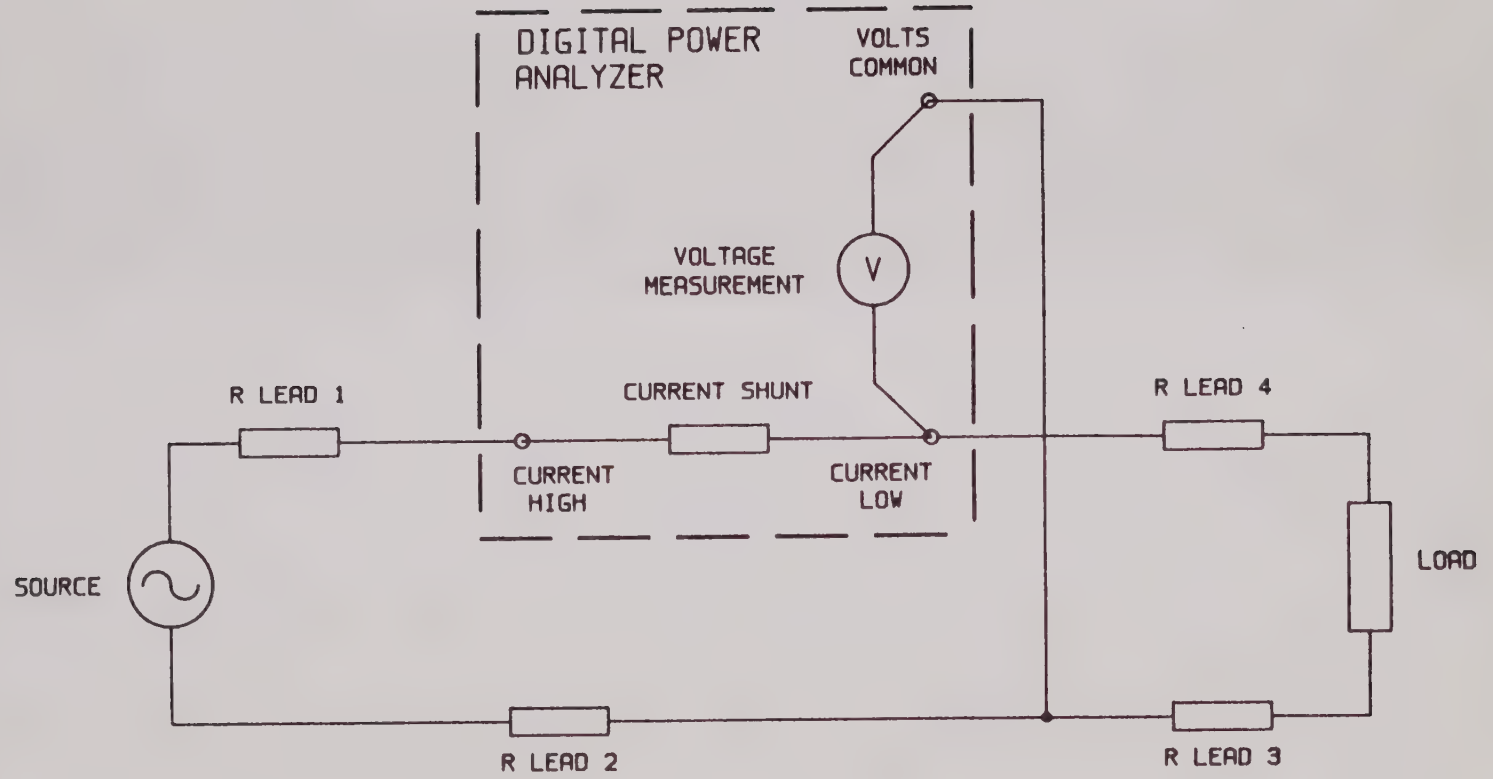


FIGURE 2 DIGITAL POWER ANALYZER ERROR SOURCES

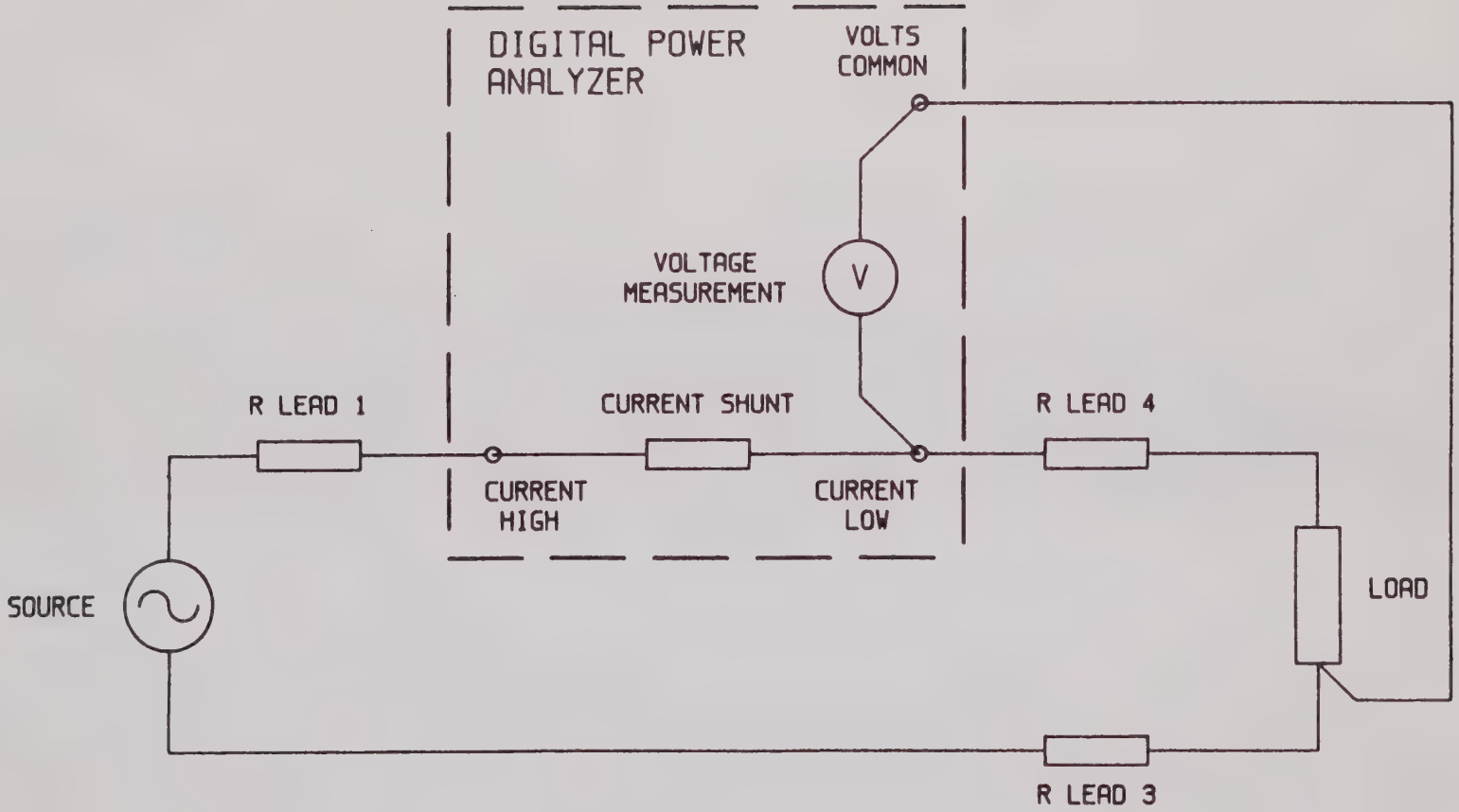


FIGURE 3 ERROR SOURCE REDUCTION

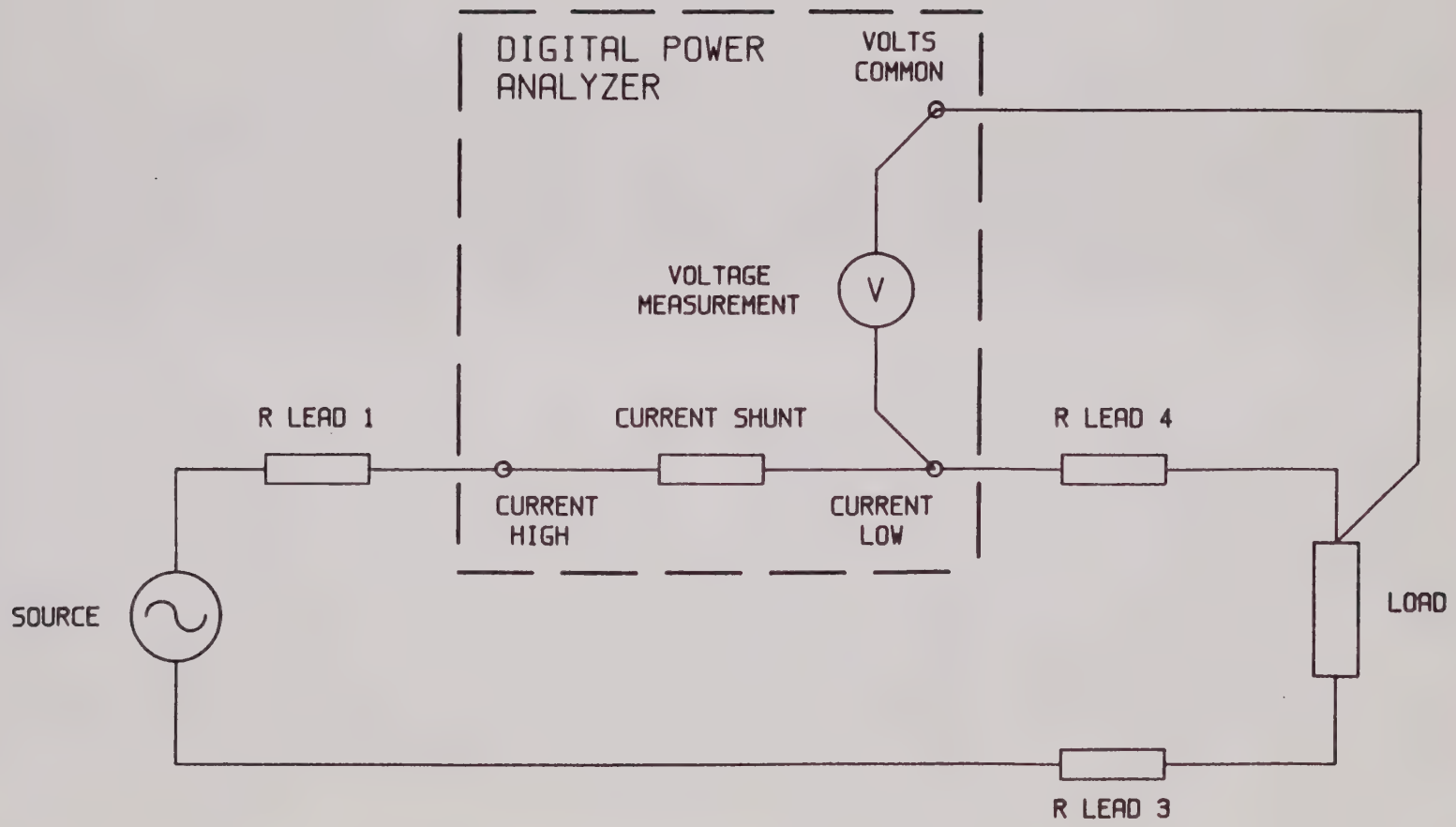


FIGURE 4 MEASURING POWER LOSS IN CONNECTING LEADS

APPLICATION NOTE AN108
MEASURING SINGLE-PHASE THREE-WIRE POWER WITH THE 2330A

108-1. General

This application note describes the connections required to measure a single-phase three-wire connected load with the 2330A.

108-2. Single-Phase Three-Wire Systems

This system consists of two 120Vrms (nominal) lines and a common grounded neutral conductor. The two 120Vrms lines are phase shifted 180 degrees. This system is sometimes called "split-phase 120/240V". 120Vrms is measured between either line and neutral, and 240Vrms line to line. Figure 1 details the line voltage relationships.

Single-phase three-wire power is available in most every residential structure in the United States. Lighting fixtures and wall outlets are powered from one line and neutral. Major appliances e.g. electric clothes dryers, electric ovens and air-conditioners are commonly powered from 240VAC using single-phase three-wire power.

108-3. 2330A Connections

Single-phase three-wire systems may be looked upon as two single-phase power measurements. The total single-phase three-wire power is the sum of the individual phase powers. Figure 2 details the connections to the 2330A. Channels A and C are used to measure the individual phase powers. The individual phase measurements are indicated in the rows for channel A and channel C.

The total single-phase three-wire power is displayed in the summing row. Be sure to select the 3-Wire-Delta configuration of the 2330A!

108-4. Measuring Neutral Current

Some applications require the measurement of neutral current as well as total power and line currents. This is easily accomplished with the 2330A. These connections are shown in Figure 3. The neutral current is passed through the ⌀B current shunt. The neutral current is displayed in the ⌀B channel row.

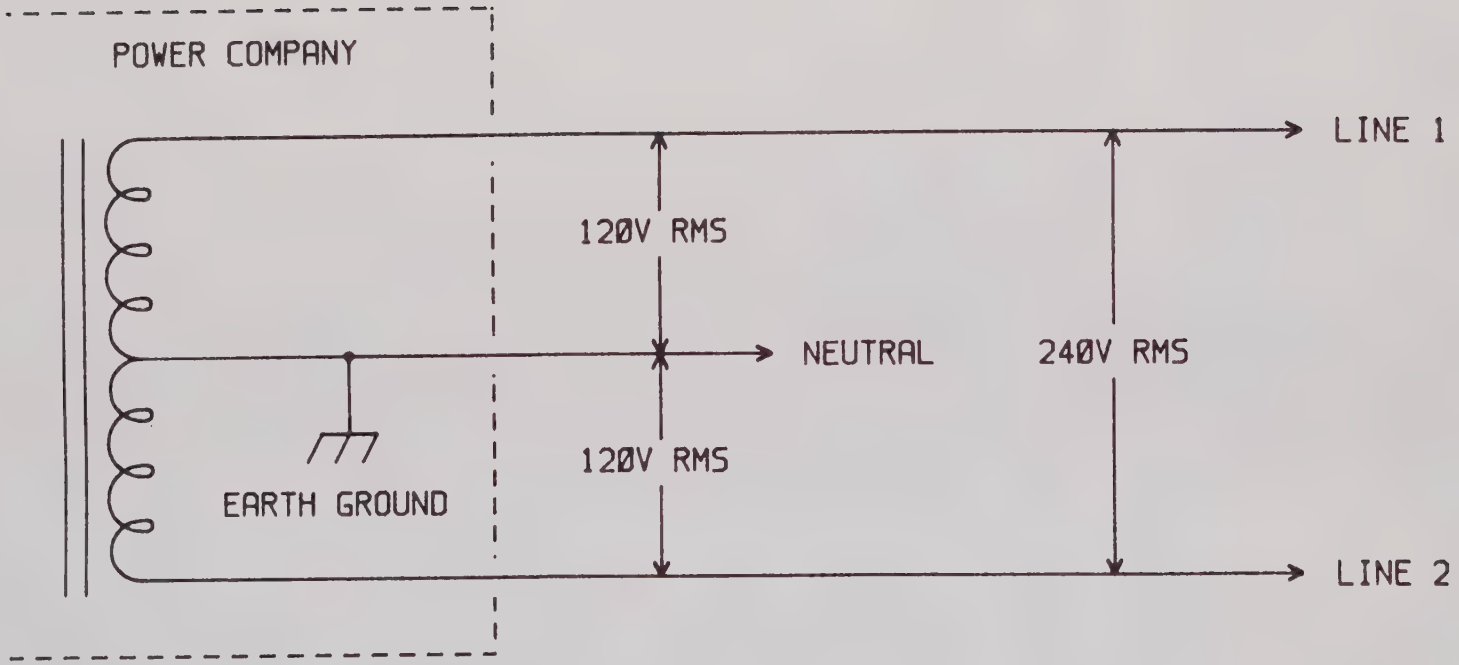


FIGURE 1 SINGLE PHASE THREE WIRE POWER

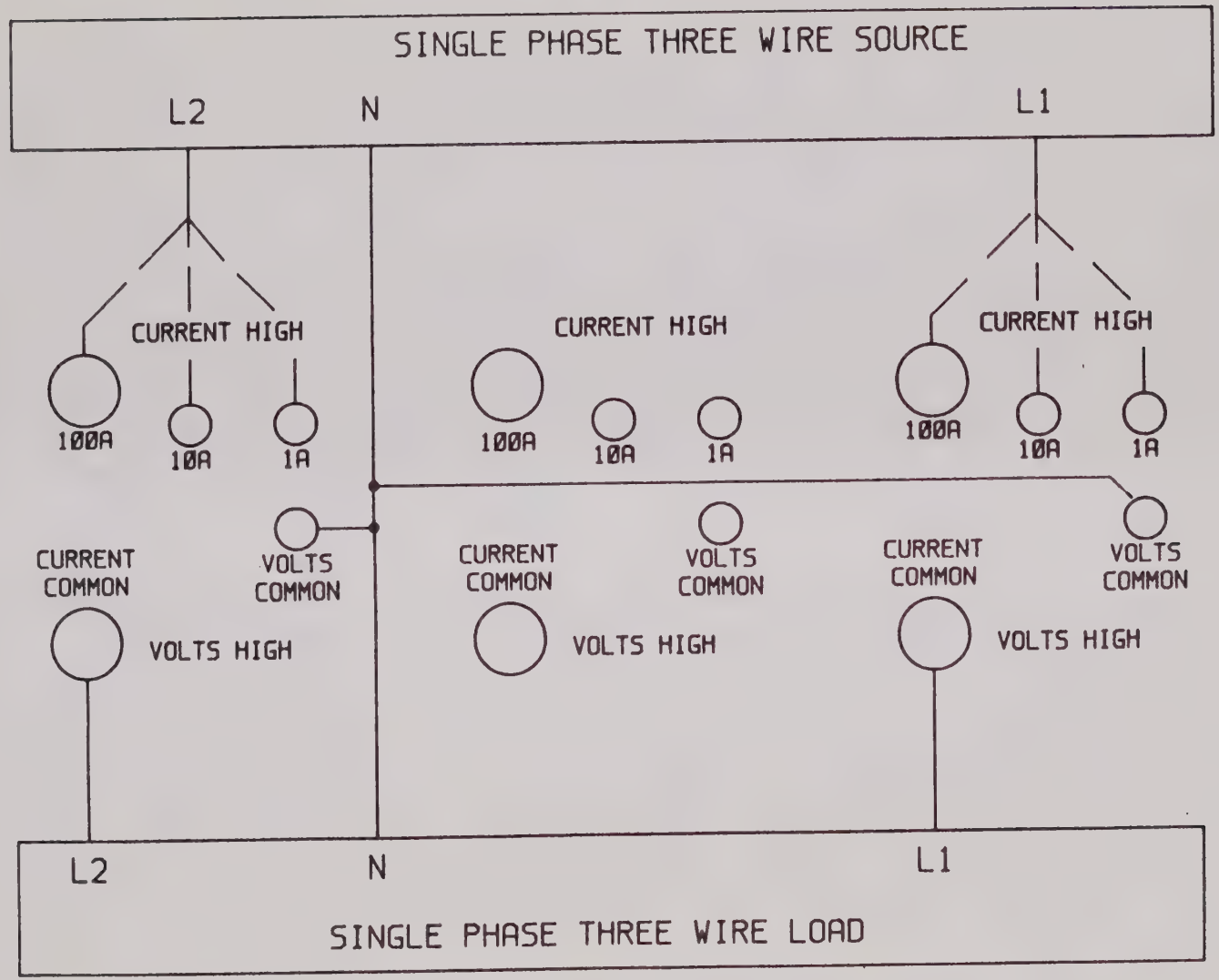


FIGURE 2 SINGLE PHASE THREE WIRE CONNECTIONS

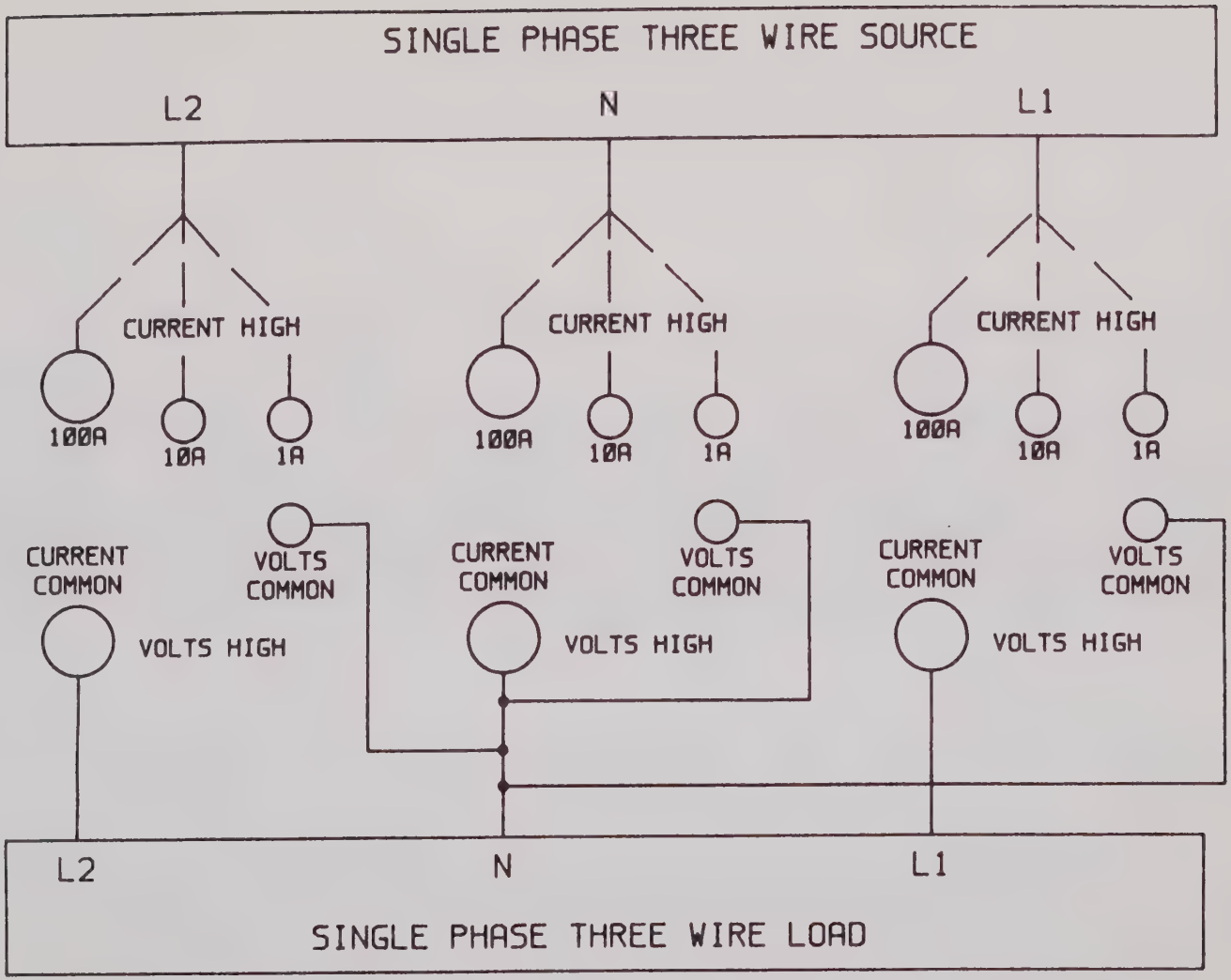


FIGURE 3 ALTERNATE SINGLE PHASE THREE WIRE CONNECTIONS

APPLICATION NOTE AN109
OPERATION OF THREE PHASE/THREE WIRE(DELTA LOAD) MEASUREMENT

109-1. General

This application note describes the procedure for testing three phase motors.

109-2. Selecting measurement mode

a) Press the **CNFG** key to select the device configuration.
b) Press the **ENTER** key to select the **Channel** menu option.
c) Press the number '**3**' key to select the [A+B+C] mode of operation.
   1. At this point the 2330A will display [A+B+C] Mode selected.
   2. The unit will automatically change to the highest range of the current shunt and hold that range.
   3. The unit will automatically configure the display to read the VRMS values in column 1, the ARMS values in column 2, and the A_PK values in column 3. The last row will display the PF, the VA and the total WATTS of all three phases.

109-3. Printing in the three phase/three wire measurement mode.

Press the **PRINT** key to print either the display or the display plus a full page report of the measurements.

109-4. Suggested operating procedure when testing motors.

a) Place the 2330A in the three phase/three wire measurement mode.
b) Select the correct current shunt to measure the motor current. This is done by pressing the '**A**' key. Press the up and down cursors to scroll through the current shunts. Once the correct shunt is shown, press the **ENTER** key. (Do not remove the current range hold as this will affect peak current measurements.)
c) Setup the motor in the test jig.
d) Press the **PKCLR** key on the 2330A to reset the current peak values. Allow the peak values to settle down on the quiescent current.
e) Start the motor.
f) The line delta voltages, the line currents, and the peak line currents will be displayed along with the PF, the VA and the WATTS.
g) Press the **PRINT** key to print a full page report of the measurements.

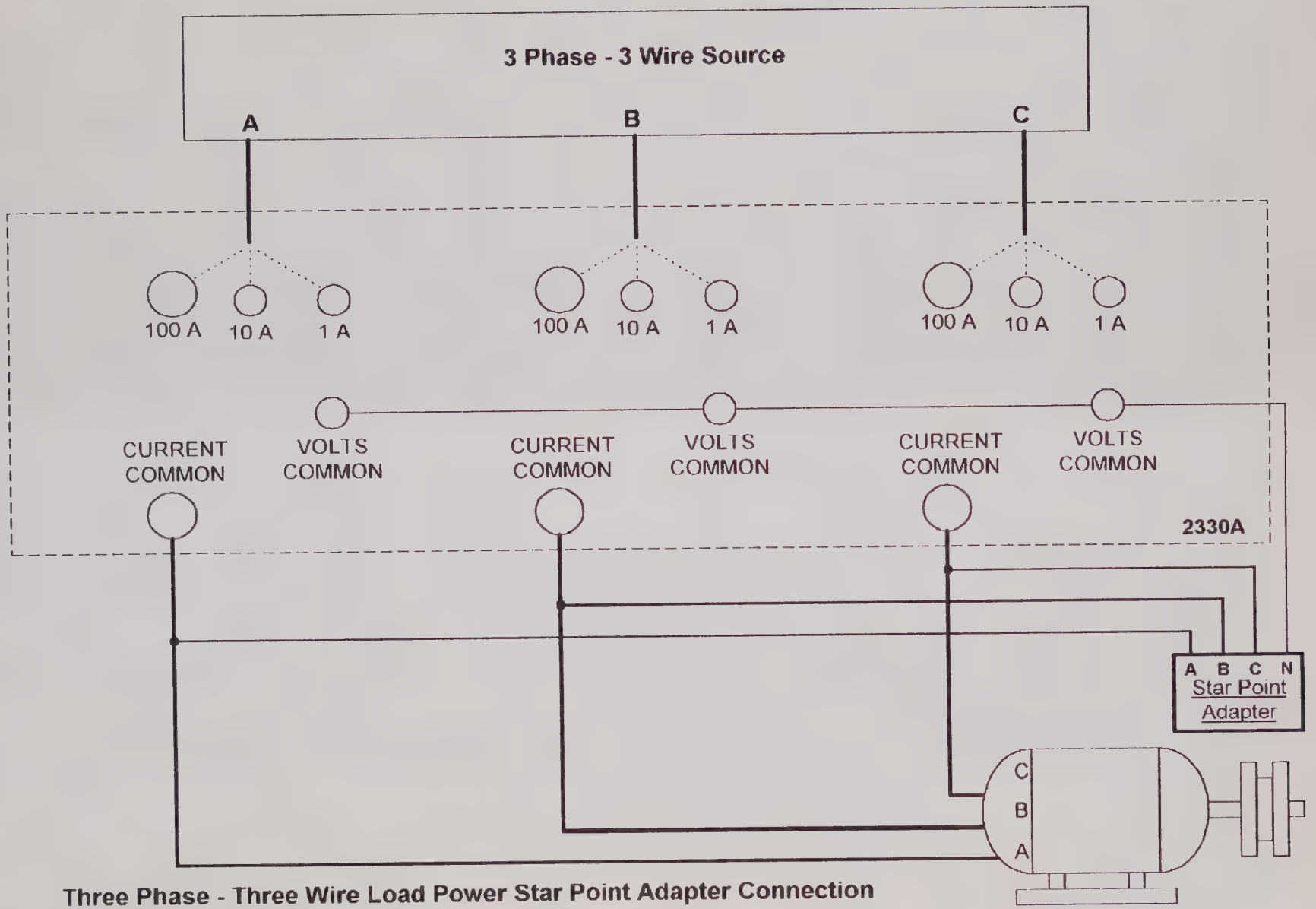
NOTE: Steps 1 and 2 only have to be performed once.

109-5. Features of the three phase/three wire measurement mode different from the other modes on the 2330A.

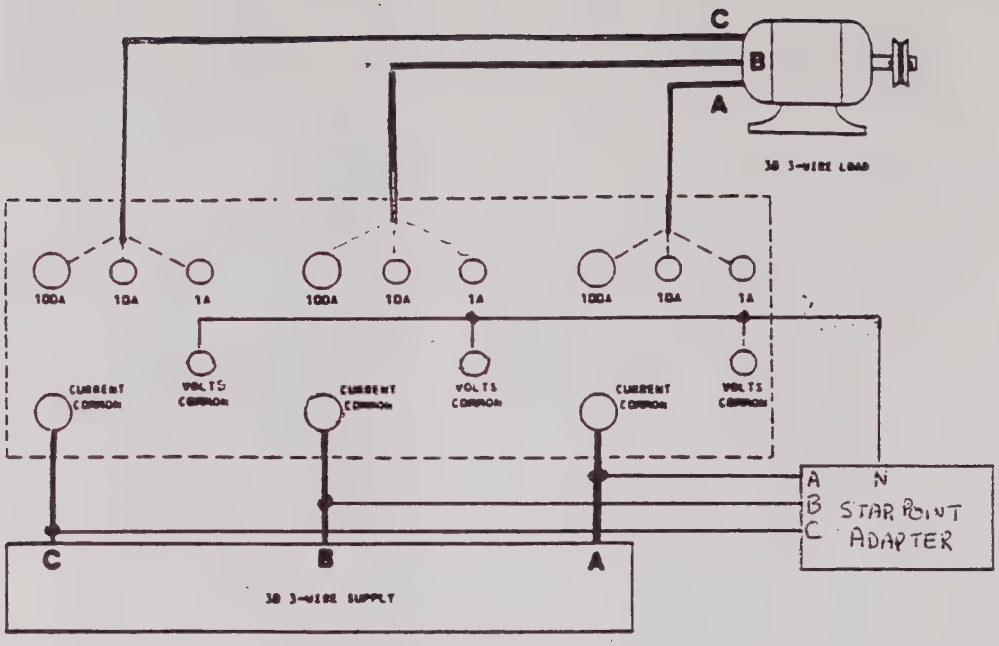
a) The VRMS voltage is displayed as the delta difference across the channels.
   -Channel A VRMS indicates the Vab voltage delta.
   -Channel B VRMS indicates the Vbc voltage delta.
   -Channel C VRMS indicates the Vca voltage delta.
b) ARMS and A_PK current is displayed as the line current for that particular channel.

-Channel A ARMS or A_PK indicates the Ia line current.
-Channel B ARMS or A_PK indicates the Ib line current.
-Channel C ARMS or A_PK indicates the Ic line current.

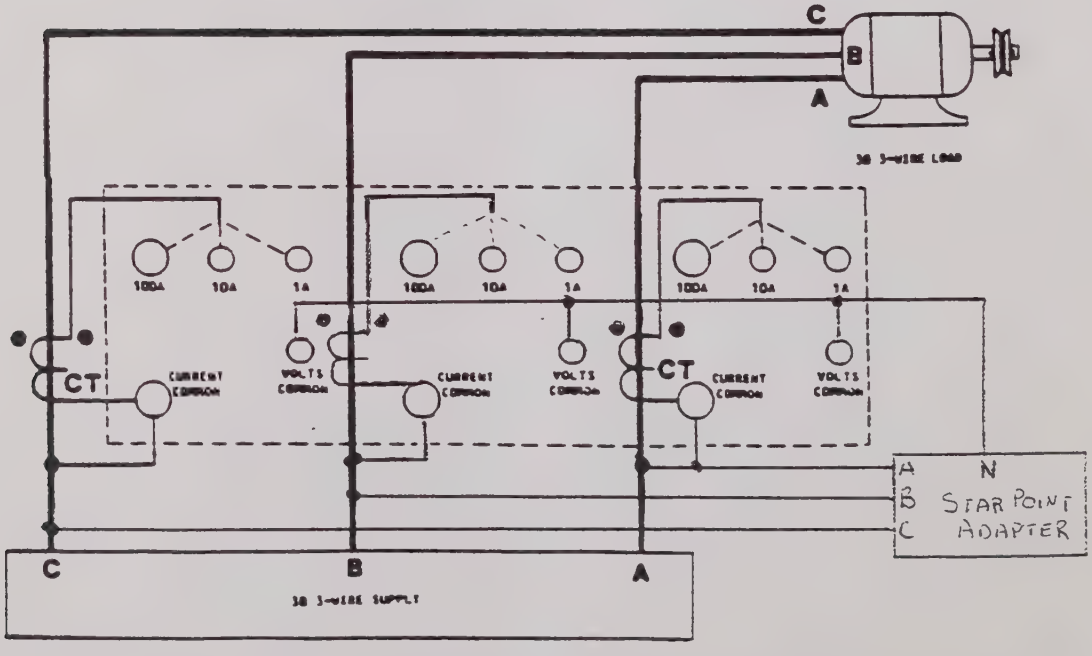
***NOTE:** The **Three phase/three wire measurement mode** also refers to the **three phase/four wire measurement mode.** The only difference is that the **three phase/three wire measurement mode** requires a virtual ground adapter (available from Valhalla Scientific), whereas, the **three phase/four wire measurement mode** doesn't.



Three Phase - Three Wire Load Power Star Point Adapter Connection



Three-Phase Three-Wire Source Power Connections

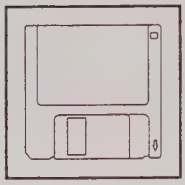


Three-Phase Three-Wire CT Source Power Connections

SECTION XI MANUAL CHANGES AND ADDENDUMS

This section contains any additional information regarding special modifications to the power analyzer or changes to the Operation Manual. If no addendums follow this page, your manual is complete as printed.

SECTION XIII PARTS LISTS



The following parts lists have been included in this manual:

2330 Chassis Assembly 2330-400
2330/01 Signal Processing PCB 2330-600
2330 Main PCB 2330-601
2330 Display PCB 2330-602
2330 Microprocessor Board 2330-604
2330-01 Main PCB 2330-608

Option IOX 2300-403

REF.DES.	STOCK #	QUANTITY A T N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	04-11017	2	Siderail	DWG 2330-205	
2	04-11013	1	Rear Panel	DWG 2330-201	
3	04-10333	3	Standard Bezel	DWG 2724-205	
4	30-00147	1	Mother Board Assembly	ASSY 2330-601	
5	04-11015	3	PCB Bracket	DWG 2330-203	
6	04-11020	1	Bottom Cover	DWG 2330-208	
7	31-00028	1	Shunt Assembly	ASSY 2330-402	
8	04-11021	1	Top Cover	DWG 2330-209	
9	30-00146	3	Signal Processing Board Assembly	ASSY 2330-600	
10	31-00027	1	Front Panel Assembly	ASSY 2330-401	
11	30-00150	1	Microprocessor Board Assembly	ASSY 2330-604	
12	04-11018	3	Wind Tunnel	DWG 2330-206	
13	91-06005	12	#6-32 x 5/16" Phil Flat 82 Deg. S.S.		
14	92-06004	17	6-32 x 1/4" Phil Truss Head S.S.		
15	90-06004	45	#6-32 x 1/4" Phil Pan S.S.		
16	98-06002	27	#6 Internal Star Washer, S.S.		
17	05-10673	22	Standoff,1/4 Hex,1/4 Lg,#6,M-F,S.S.	Raf 4530-632-SS-0	
18	05-10350	7	Grommet, caterpillar, .18" thick	Smith 2694	
19	98-06001	29	#6 Split Lock Washer,STD,S.S.		
20	97-06000	9	#6-32 Standard Hex Nut, S.S.		
21	98-04001	6	#4 Split Lock Washer S.S.		
22	90-04005	6	#4-40 x 5/16" Phil Pan S.S.		
23	90-04206	2	#4-40 x 3/8" Phil Pan Black		
24	91-04005	8	#4-40 x 5/16" Phil Flat 82 Deg. S.S.		
25	04-11029	1	Display Filter	DWG 2330-214	
26	04-11019	1	Flip Lid	DWG 2330-207	
27	05-10633	6	Card Guide, Snap in, 4.125 lg., 0.38 wide	Unitrack S-583040	
28	05-10317	2	Washer, nylon, shoulder, #4	Keystone 3053	
29	08-10037	1	AC Power Harness	ASSY 2330-050	
30	30-00152	1	Frequency Subtraction Bd. Assy	ASSY 2330-605	
31	05-10019	10	Cable tie, 4"x 1/8"	Panduit WRN-4	
32	97-04001	2	#4-40 Radio Hex Nut S.S.		
33	08-10046	1	Harmonic Signal Cable	ASSY 2330-059	
34	08-10048	1	Frequency Subtraction Input Cable	ASSY 2330-061	
35	99-99009	1	THREADLOCK MEDIUM	Loctite 222	
36	70-00006	1	3/8" Black Shrink Tubing	3M 3000375BK	
37	05-10441	4	Tie-wrap block, small	Panduit ABMM-AT	
38	04-10671	4	7.00 in. Handle(Plastic)	DWG 2700-237	
39	91-08004	8	#8-32 x 1/4" Phil Flat 82 Deg. S.S.		
40	91-04004	2	#4-40 x 1/4" Phil Flat 82Deg. S.S.		
41	05-10808	2	Dual Tilting Feet (Plastic,Gray)	Elma Electronics 63-018S	
42	05-10361	2	Foot, hard, rubber, grey	ACC.Rubber 2095W-017-GREY	
43	08-10050	1	Frequency Subtraction Cable	ASSY 2330-062	
44	05-10018	1	Fuseholder, panel mount	Littlefuse 345061	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	98-04002	2			#4 Internal Star Washer S.S.		
2	90-04006	2			#4-40 x 3/8" Phil Pan S.S.		
3	70-11022	4			22AWG TFE Sleeving	ATC TFT 22	
4	80-00022	4			22AWG Buss Wire	1BB-2201 ANIXTER	
5	05-10010	2			Spacer,nylon discrete comp.	Bivar 904-.250	
6	70-00003	2			3/16" Black Shrink Tubing	3000187 BLK 3M	
A1	04-30285	1			Signal Processing Board	DWG 2330-700	
C101	02-20999	1			F.S.(CM05) Mica		
C102	02-20999	1			F.S.(CM05) Mica		
C103	02-20999	1			F.S.(CM05) Mica		
C104	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C105	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
C106	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C107	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
C108	02-20999	1			F.S.(CM05) Mica		
C109	02-20999	1			F.S.(CM05) Mica		
C110	02-20999	1			F.S.(CM05) Mica		
C111	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C112	02-30011	1			4.7u 35V Tantalum Bead	TDC475K035WLE	
C113	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C114	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C115	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C116	02-90005	1			0.1uF 5% 50V Polycarbonate	IMB RA7A104J	
C117	02-20003	1			5p 500V Mica	CM05FD050J03	
C118	02-30000	1			4.7uF 16V Tantalum Bead	TAP475K016SP	
C119	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C120	02-30011	1			4.7u 35V Tantalum Bead	TDC475K035WLE	
C121	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C122	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C123	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C124	02-90004	1			0.01uF 5% 50V Polycarbonate	IBM RA7A103J	
C125	02-90005	1			0.1uF 5% 50V Polycarbonate	IMB RA7A104J	
C126	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C127	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C128	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C129	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C130	02-30007	1			2.2uF 10V Tantalum Bead	AVX TAP225K010SP	
C131	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C132	02-30007	1			2.2uF 10V Tantalum Bead	AVX TAP225K010SP	
C133	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C134	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C135	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C136	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C137	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C138	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C139	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C140	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C141	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C142	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C143	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C144	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
C145	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C146	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C147	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C148	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C149	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C150	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C151	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C152	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C153	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C154	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C155	02-60011	1			1000pF,100V,Mylar,5%	WIMA,FKS2-1000P	
C156	02-60011	1			1000pF,100V,Mylar,5%	WIMA,FKS2-1000P	
C157	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C158	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C160	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C161	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C162	02-90005	1			0.1uF 5% 50V Polycarbonate	IMB RA7A104J	
C164	02-20006	1			3p 500V Mica	CM05FD030J03	
C165	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C201	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C202	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C203	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C204	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C205	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C206	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
C207	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C208	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
C209	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
C210	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
C211	02-10006	1			0.01uF 50V Ceramic disc	Illinois 103GR050-Z	
C212	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
C213	02-60002	1			0.1uF 250V Mylar	Illinois 104MSR250K	
CR101	03-20000	1			Diode, general purpose	1N4148 or 1N914	
CR102	03-20028	1			Diode, signal, schottky	1N5711	
CR103	03-20028	1			Diode, signal, schottky	1N5711	
CR104	03-20000	1			Diode, general purpose	1N4148 or 1N914	
CR105	03-20000	1			Diode, general purpose	1N4148 or 1N914	
CR106	03-20007	1			Zener, reference, 6.3V, 10ppm/c, 5%	1N827	
CR107	03-20007	1			Zener, reference, 6.3V, 10ppm/c, 5%	1N827	
CR201	03-20000	1			Diode, general purpose	1N4148 or 1N914	
CR202	03-20000	1			Diode, general purpose	1N4148 or 1N914	
CR203	03-20000	1			Diode, general purpose	1N4148 or 1N914	
CR204	03-20000	1			Diode, general purpose	1N4148 or 1N914	
CR205	03-20000	1			Diode, general purpose	1N4148 or 1N914	
IC101	03-30200	1			Dual 4 to 1 analog switch (CMOS)	4052BE	
IC102	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC103	03-30133	1			Quad general purpose comparator	LM339N	
IC104	03-30201	1			Dual general purpose opto-isolator	ILCT6 or MCT6	
IC105	03-30133	1			Quad general purpose comparator	LM339N	
IC106	03-30104	1			General purpose uncompensated JFET Op-amp	LF357H or N	
IC107	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
IC108	03-30045	1			RMS-to-DC Converter	Analog Devices AD536AJH	
IC109	03-30202	1			Analog Multiplier	Analog Devices AD534KH	
IC110	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC111	03-30531	1			High Speed JFET Op-Amp	Analog Devices AD845JN	
IC112	03-30201	1			Dual general purpose opto-isolator	ILCT6 or MCT6	
IC113	03-30045	1			RMS-to-DC Converter	Analog Devices AD536AJH	
IC114	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC115	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC116	03-30622	1			Monolithic Peak Detector	PMI PKD-01EP	
IC117	03-30133	1			Quad general purpose comparator	LM339N	
IC118	03-30145	1			High gain high speed Opto-isolator	6N136	
IC119	03-30145	1			High gain high speed Opto-isolator	6N136	
IC120	03-30145	1			High gain high speed Opto-isolator	6N136	
IC121	03-30145	1			High gain high speed Opto-isolator	6N136	
IC122	03-30145	1			High gain high speed Opto-isolator	6N136	
IC123	03-30073	1			Comparator,JFET	LF311H or TL311	
IC124	03-30201	1			Dual general purpose opto-isolator	ILCT6 or MCT6	
IC125	03-30201	1			Dual general purpose opto-isolator	ILCT6 or MCT6	
IC126	03-30073	1			Comparator,JFET	LF311H or TL311	
IC127	03-30093	1			Very High Speed Opto-Isolator	Hewlett Packard HCPL-2601	
IC201	03-30185	1			Quad general purpose Opto-isolator	Litronix ILQ-74A	
IC202	03-30185	1			Quad general purpose Opto-isolator	Litronix ILQ-74A	
PL101	05-10587	1			64 Pin DIN Plug, Rt Angl, PCB Mtg, 3 Row Male	Elco 10-8457-096-002-026	
PL102	05-10300	1			Wafer, 10 pin, .156 spacing	Molex 09-67-1103	
PL103	05-10818	1			Header, 4 Pin, Straight, .1"sp, Gold, Locking	Molex 22-11-2042	
R101	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R102	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R103	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R104	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R105	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R106	01-10048	1			1M 1% 50ppm/C 1/2W Metal Film	RN65C1004F	
R107	01-10108	1			7.5K 1% 50ppm/C 1/4W Metal Film	RN60C7501F	
R108	01-10008	1			10K 1% 50ppm/C 1/4W Metal Film	RN60C1002F	
R109	01-10133	1			845 1% 50ppm/C 1/4W Metal Film	RN60C8450F	
R110	01-10101	1			3.09K 1% 50ppm/C 1/4W Metal Film	RN60C3091F	
R111	01-10113	1			8.06K 1% 50ppm/C 1/4W Metal Film	RN60C8061F	
R112	01-01043	1			1.5K 5% 1/4W Carbon Film	RC07GF152J	
R113	01-01085	1			200K 5% 1/4W Carbon Film	RC07GF204J	
R114	01-01043	1			1.5K 5% 1/4W Carbon Film	RC07GF152J	
R115	01-01085	1			200K 5% 1/4W Carbon Film	RC07GF204J	
R116	01-10180	1			250K 0.1% 5ppm/C 1/8W Metal Film	PRP 1/8W - 250K - 0.1% - 5PPM	
R118	01-10084	1			4.53K 1% 50ppm/C 1/4W Metal Film	RN60C4531F	
R119	01-10218	1			4.12K 1% 50ppm/C 1/4W Metal Film	RN60C4121F	
R120	01-10245	1			1.37K 1% 50ppm/C 1/4W Metal Film	RN60C1371F	
R121	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R123	01-01047	1			2.4K 5% 1/4W Carbon Film	RC07GF242J	
R124	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R125	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R126	01-01047	1			2.4K 5% 1/4W Carbon Film	RC07GF242J	
R127	01-10051	1			100 1% 50ppm/C 1/4W Metal Film	RN60C1000F	
R128	01-10061	1			4.99K 1% 50ppm/C 1/4W Metal Film	RN60C4991F	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R129	01-10061	1			4.99K 1% 50ppm/C 1/4W Metal Film	RN60C4991F	
R130	01-10037	1			10K 0.1% 50ppm/C 1/4W Metal Film	RN60C1002B	
R131	01-10061	1			4.99K 1% 50ppm/C 1/4W Metal Film	RN60C4991F	
R132	01-10061	1			4.99K 1% 50ppm/C 1/4W Metal Film	RN60C4991F	
R133	01-10082	1			11K 1% 50ppm/C 1/4W Metal Film	RN60C1102F	
R134	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R135	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R136	01-10008	1			10K 1% 50ppm/C 1/4W Metal Film	RN60C1002F	
R137	01-10008	1			10K 1% 50ppm/C 1/4W Metal Film	RN60C1002F	
R138	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R139	01-10008	1			10K 1% 50ppm/C 1/4W Metal Film	RN60C1002F	
R140	01-01050	1			3.3K 5% 1/4W Carbon Film	RC07GF332J	
R141	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R142	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R143	01-01045	1			2K 5% 1/4W Carbon Film	RC07GF202J	
R144	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R145	01-01085	1			200K 5% 1/4W Carbon Film	RC07GF204J	
R146	01-01045	1			2K 5% 1/4W Carbon Film	RC07GF202J	
R147	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R148	01-01085	1			200K 5% 1/4W Carbon Film	RC07GF204J	
R149	01-01045	1			2K 5% 1/4W Carbon Film	RC07GF202J	
R150	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R151	01-01085	1			200K 5% 1/4W Carbon Film	RC07GF204J	
R152	01-01045	1			2K 5% 1/4W Carbon Film	RC07GF202J	
R153	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R154	01-01085	1			200K 5% 1/4W Carbon Film	RC07GF204J	
R155	01-01045	1			2K 5% 1/4W Carbon Film	RC07GF202J	
R156	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R157	01-01085	1			200K 5% 1/4W Carbon Film	RC07GF204J	
R158	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R160	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R161	01-10154	1			73.2K 1% 50ppm/C 1/4W Metal Film	RN60C7322F	
R162	01-10027	1			4.02K 1% 50ppm/C 1/4W Metal Film	RN60C4021F	
R163	01-10027	1			4.02K 1% 50ppm/C 1/4W Metal Film	RN60C4021F	
R164	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R165	01-01053	1			4.7K 5% 1/4W Carbon Film	RC07GF472J	
R166	01-01045	1			2K 5% 1/4W Carbon Film	RC07GF202J	
R167	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R168	01-01033	1			470 5% 1/4W Carbon Film	RC07GF471J	
R169	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R170	01-01053	1			4.7K 5% 1/4W Carbon Film	RC07GF472J	
R171	01-01045	1			2K 5% 1/4W Carbon Film	RC07GF202J	
R172	01-01081	1			100K 5% 1/4W Carbon Film	RC07GF104J	
R173	01-01033	1			470 5% 1/4W Carbon Film	RC07GF471J	
R174	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R175	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R176	01-01062	1			12K 5% 1/4W Carbon Film	RC07GF123J	
R177	01-01094	1			560K 5% 1/4W Carbon Film	RC07GF564J	
R178	01-01025	1			200 5% 1/4W Carbon Film	RC07GF201J	
R201	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R202	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R203	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R204	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R205	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
RN201	01-40001	1			8 x 470 Network	A-B 316B-471	
RV101	01-50025	1			100 End Adjust	Beckman 89PR100ohm	
RV102	01-50025	1			100 End Adjust	Beckman 89PR100ohm	
RV103	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV104	01-50041	1			2K End Adjust	Beckman 89PR2K	
RV105	01-50025	1			100 End Adjust	Beckman 89PR100ohm	
RV106	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV107	01-50042	1			5K End Adjust	Beckman 89PR5K	
RV108	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV109	01-50022	1			1K End Adjust	Beckman 89PR1K	
RV110	01-50022	1			1K End Adjust	Beckman 89PR1K	
RV111	01-50043	1			200 End Adjust	Beckman 89PR200ohm	
RV114	01-50022	1			1K End Adjust	Beckman 89PR1K	
RV115	01-50058	1			50K Square, End Adjust	Beckman 67XR50K	
RLA	05-03070	1			Relay,Reed,1 Form A,DIP-14,12VDC	Clare,PRMA1A12	
RLB	05-03070	1			Relay,Reed,1 Form A,DIP-14,12VDC	Clare,PRMA1A12	
RLC	05-03070	1			Relay,Reed,1 Form A,DIP-14,12VDC	Clare,PRMA1A12	
RLD	05-03070	1			Relay,Reed,1 Form A,DIP-14,12VDC	Clare,PRMA1A12	
RLE	05-03070	1			Relay,Reed,1 Form A,DIP-14,12VDC	Clare,PRMA1A12	
TR201	03-10013	1			NPN Transistor (TO92)	2N4401	
TR202	03-10013	1			NPN Transistor (TO92)	2N4401	
TR203	03-10013	1			NPN Transistor (TO92)	2N4401	
TR204	03-10013	1			NPN Transistor (TO92)	2N4401	
TR205	03-10013	1			NPN Transistor (TO92)	2N4401	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	05-10838	8			Heatsink, TO-220, Black Anodize	AAVID #576802B04000	
2	05-10903	1			Heatsink, Wave Solder, 1" High (TO-3) .062 Bd	AAVID 568203B00600	
3	96-00043	2			#6-32 x 9/16" Phil Pan Zinc Plated		
4	98-06002	2			#6 Internal Star Washer, S.S.		
5	05-10850	1			Heatsink, Expandable Collar (TO-3)	Aavid 579103-C00000	
6	05-10869	1			Insulator, TO-3	Berquist QII-29	05-10232
8	80-02218	6			18awg Wire, Red TFE	M16878/4-BHE-2	
9	80-02018	6			18awg Wire, Black TFE	M16878/4-BHE-0	
10	05-10693	1			Conn. Housing, 2 Pin, Locking, 0.156 SP.	Molex 09-50-8023	
11	05-10301	2			Crimp Terminal 0.156 sp. housing, 18-24 AWG	Molex 08-50-0106	
12	98-04002	6			#4 Internal Star Washer S.S.		
13	90-04006	6			#4-40 x 3/8" Phil Pan S.S.		
14	97-04001	6			#4-40 Radio Hex Nut S.S.		
15	80-00020	1			20AWG Buss Wire		
17	05-10582	1			Cable Tie 8.0"lg x .10"wide	Panduit PLT2M	
18	80-00022	1			22AWG Buss Wire	1BB-2201 ANIXTER	
19	70-11022	1			22AWG TFE Sleeving	ATC TFT 22	
A1	04-30286	1			Mother Board	DWG 2330-701	
C102	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C103	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C104	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C105	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C106	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C107	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C108	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C109	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C110	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C111	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C112	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C113	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C114	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C115	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C116	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C117	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C118	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C119	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C120	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C121	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C122	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C123	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C124	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C125	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C126	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C127	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C128	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C129	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C130	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C131	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C132	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C133	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C134	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
C135	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C136	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C137	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C138	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C139	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C140	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C141	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C142	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C143	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C202	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C203	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C204	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C205	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C206	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C207	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C208	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C209	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C210	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C211	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C212	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C213	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C214	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C215	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C216	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C217	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C218	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C219	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C220	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C221	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C222	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C223	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C224	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C225	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C226	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C227	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C228	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C229	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C230	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C231	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C232	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C233	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C234	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C235	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C236	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C237	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C238	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C239	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C240	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C241	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C242	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C243	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
C302	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C303	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C304	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C305	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C306	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C307	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C308	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C309	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C310	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C311	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C312	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C313	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C314	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C315	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C316	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C317	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C318	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C319	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C320	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C321	02-60000	1			.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C322	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C323	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C324	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C325	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C326	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C327	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C328	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C329	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C330	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C331	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C332	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C333	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C334	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C335	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C336	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C337	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C338	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C339	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C340	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C341	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C342	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C343	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C501	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C502	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C503	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C504	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C505	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C506	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C511	02-40012	1			15000uF 16V Aluminum	Illinois 159TTA016	
C512	02-30014	1			100u 10V Tantalum Bead	AVX TAP106K025SP	
C521	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
C522	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C523	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C524	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C525	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
CR111	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR112	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR113	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR114	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR211	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR212	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR213	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR214	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR311	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR312	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR313	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR314	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR501	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR502	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR503	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR504	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR505	03-20091	1			Rectifier, Schottky, 9A, 35V	IR 90SQ035	
CR506	03-20091	1			Rectifier, Schottky, 9A, 35V	IR 90SQ035	
IC102	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC103	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC104	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC106	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC107	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC108	03-30036	1			Regulator,+15V,0.5A,TO202 or TO220	78M15CP or LM340T-15	
IC109	03-30037	1			Regulator,-15V,0.5A,TO202 or TO220	79M15CP or LM320T-15	
IC110	03-30449	1			10v Pretrimmed Volt. Ref.	Anal Dev AD581JH	
IC111	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC112	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC113	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC114	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC115	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC116	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC117	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC118	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC202	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC203	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC204	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC206	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC207	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC208	03-30036	1			Regulator,+15V,0.5A,TO202 or TO220	78M15CP or LM340T-15	
IC209	03-30037	1			Regulator,-15V,0.5A,TO202 or TO220	79M15CP or LM320T-15	
IC210	03-30449	1			10v Pretrimmed Volt. Ref.	Anal Dev AD581JH	
IC211	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC212	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC213	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC214	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC215	03-30170	1			Low Noise, low drift Op-amp	OP07DP	

REF.DES.	STOCK #	QUANTITY A	QUANTITY T	QUANTITY N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
IC216	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC217	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC218	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC302	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC303	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC304	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC306	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC307	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC308	03-30036	1			Regulator,+15V,0.5A,TO202 or TO220	78M15CP or LM340T-15	
IC309	03-30037	1			Regulator,-15V,0.5A,TO202 or TO220	79M15CP or LM320T-15	
IC310	03-30449	1			10v Pretrimmed Volt. Ref.	Anal Dev AD581JH	
IC311	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC312	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC313	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC314	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC315	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC316	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC317	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC318	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC501	03-30036	1			Regulator,+15V,0.5A,TO202 or TO220	78M15CP or LM340T-15	
IC502	03-30037	1			Regulator,-15V,0.5A,TO202 or TO220	79M15CP or LM320T-15	
IC503	03-30651	1			3A Low Dropout Pos. Adj. Regulator	LT LT1085CK	
IC509	03-30095	1			Dual D-Type Flip Flop	74LS74N or 74ALS74N (ALT 03-30338)	
IC510	03-30095	1			Dual D-Type Flip Flop	74LS74N or 74ALS74N (ALT 03-30338)	
IC511	03-30085	1			Regulator,+8V,0.5A,TO202 or TO220	78M08CP or LM340T-8.0	
IC512	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC513	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
J2	05-10527	1			Connector,34 pin,0.1x0.1,with lock	Robinson Nugent IDH-34K-S3-TG-EL-1K	
J4	05-10527	1			Connector,34 pin,0.1x0.1,with lock	Robinson Nugent IDH-34K-S3-TG-EL-1K	
PL101	05-10586	1			64 pin DIN Socket, PCB Mtg (3 row)	ELCO 20-8457-096-002-026	
PL201	05-10586	1			64 pin DIN Socket, PCB Mtg (3 row)	ELCO 20-8457-096-002-026	
PL301	05-10586	1			64 pin DIN Socket, PCB Mtg (3 row)	ELCO 20-8457-096-002-026	
PL501	05-10877	1			Header, 2 pin, Locking, 0.156 sp.	Molex 26-61-4020	
PL503	05-10898	1			Header, 12pin, 0.1"sp, Locking	Molex 22-11-2122	
PL505	05-10817	1			Header, 2 Pin, Straight, .1"sp, Gold, Locking	Molex 22-11-2022	
PL508	05-10527	1			Connector,34 pin,0.1x0.1,with lock	Robinson Nugent IDH-34K-S3-TG-EL-1K	
PL509	05-10877	1			Header, 2 pin, Locking, 0.156 sp.	Molex 26-61-4020	
R105	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R106	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R107	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R108	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R109	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R113	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R114	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R115	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R116	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R117	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R121	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R122	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R123	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R124	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R125	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R129	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R130	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R131	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R132	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R133	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R136	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R137	01-10047	1			49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	
R138	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R139	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R140	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R141	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R142	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R143	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R144	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R145	01-10188	1			133 1% 5ppm/C 1/8W Metal Film	PRP 1/8W - 133OHM - 1% - 5PPM	
R146	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R148	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R149	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R150	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R151	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R152	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R153	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R154	01-10026	1			374 1% 50ppm/C 1/4W Metal Film	RN60C3740F	
R155	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R156	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R157	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R158	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R159	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R205	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R206	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R207	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R208	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R209	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R213	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R214	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R215	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R216	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R217	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R221	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R222	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R223	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R224	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R225	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R229	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R230	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R231	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R232	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R233	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R236	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R237	01-10047	1			49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R238	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R239	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R240	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R241	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R242	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R243	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R244	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R245	01-10188	1			133 1% 5ppm/C 1/8W Metal Film	PRP 1/8W - 133OHM - 1% - 5PPM	
R246	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R248	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R249	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R250	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R251	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R252	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R253	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R254	01-10026	1			374 1% 50ppm/C 1/4W Metal Film	RN60C3740F	
R255	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R256	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R257	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R258	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R259	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R303	01-01083	1			150K 5% 1/4W Carbon Film	RC07GF154J	
R305	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R306	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R307	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R308	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R309	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R313	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R314	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R315	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R316	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R317	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R321	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R322	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R323	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R324	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R325	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R329	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R330	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R331	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R332	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R333	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R336	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R337	01-10047	1			49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	
R338	01-10006	1			100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R339	01-10111	1			1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R340	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R341	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R342	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R343	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R344	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R345	01-10188	1			133 1% 5ppm/C 1/8W Metal Film	PRP 1/8W - 133OHM - 1% - 5PPM	
R346	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R348	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R349	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R350	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R351	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R352	01-20177	1			500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R353	01-20149	1			1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R354	01-10026	1			374 1% 50ppm/C 1/4W Metal Film	RN60C3740F	
R355	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R356	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R357	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R358	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R359	01-01054	1			5.1K 5% 1/4W Carbon Film	RC07GF512J	
R517	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R518	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R519	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R520	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R521	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R522	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R523	01-01043	1			1.5K 5% 1/4W Carbon Film	RC07GF152J	
R524	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R525	01-01043	1			1.5K 5% 1/4W Carbon Film	RC07GF152J	
R526	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R527	01-01043	1			1.5K 5% 1/4W Carbon Film	RC07GF152J	
R528	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R529	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R530	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R533	01-10282	1			121 1% 50ppm/C 1/2W Metal Film	RN60C1210F	
R534	01-10173	1			365 1% 50ppm/C 1/4W Metal Film	RN60C3650F	
R535	01-10323	1			6.04K 0.1% 5ppm/C 1/8W Metal Film	PRP 1/8W 6.04K 0.1% 5PPM	
R536	01-10379	1			2.80K .1% 5ppm/C 1/8W Metal Film	PRP 1/8W 2.80K .1% 5PPM	
R537	01-10353	1			3.01K 0.1% 5ppm/C Metal Film	PRP 1/4W 3.01K 0.1% 5PPM	
R538	01-10323	1			6.04K 0.1% 5ppm/C 1/8W Metal Film	PRP 1/8W 6.04K 0.1% 5PPM	
R539	01-10323	1			6.04K 0.1% 5ppm/C 1/8W Metal Film	PRP 1/8W 6.04K 0.1% 5PPM	
RV101	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV102	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV103	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV104	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV105	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV106	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV107	01-50018	1			10 Top Adjust	Beckman 68WR10ohm	
RV108	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV109	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV110	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV111	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV201	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV202	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV203	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV204	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV205	01-50028	1			50K Top Adjust	Beckman 68WR50K	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
RV206	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV207	01-50018	1			10 Top Adjust	Beckman 68WR10ohm	
RV208	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV209	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV210	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV211	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV301	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV302	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV303	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV304	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV305	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV306	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV307	01-50018	1			10 Top Adjust	Beckman 68WR10ohm	
RV308	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV309	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV310	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV311	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
T101	04-20086	1			Power Transformer Dual 18V	Signal DST-5-36	
T201	04-20039	1			Power XFMR	Signal,DST-4-36	
T301	04-20039	1			Power XFMR	Signal,DST-4-36	
T501	04-20086	1			Power Transformer Dual 18V	Signal DST-5-36	
T502	04-20040	1			Power XFMR	Signal,DPC-12-2000	
TP101	05-10290	1			Test Hook, PCB	Vector K32-2	
TP102	05-10290	1			Test Hook, PCB	Vector K32-2	
TP103	05-10290	1			Test Hook, PCB	Vector K32-2	
TP104	05-10290	1			Test Hook, PCB	Vector K32-2	
TP105	05-10290	1			Test Hook, PCB	Vector K32-2	
TP106	05-10290	1			Test Hook, PCB	Vector K32-2	
TP107	05-10290	1			Test Hook, PCB	Vector K32-2	
TP201	05-10290	1			Test Hook, PCB	Vector K32-2	
TP202	05-10290	1			Test Hook, PCB	Vector K32-2	
TP203	05-10290	1			Test Hook, PCB	Vector K32-2	
TP204	05-10290	1			Test Hook, PCB	Vector K32-2	
TP205	05-10290	1			Test Hook, PCB	Vector K32-2	
TP206	05-10290	1			Test Hook, PCB	Vector K32-2	
TP207	05-10290	1			Test Hook, PCB	Vector K32-2	
TP301	05-10290	1			Test Hook, PCB	Vector K32-2	
TP302	05-10290	1			Test Hook, PCB	Vector K32-2	
TP303	05-10290	1			Test Hook, PCB	Vector K32-2	
TP304	05-10290	1			Test Hook, PCB	Vector K32-2	
TP305	05-10290	1			Test Hook, PCB	Vector K32-2	
TP306	05-10290	1			Test Hook, PCB	Vector K32-2	
TP307	05-10290	1			Test Hook, PCB	Vector K32-2	
TP501	05-10290	1			Test Hook, PCB	Vector K32-2	
TP502	05-10290	1			Test Hook, PCB	Vector K32-2	

REF.DES.	STOCK #	QUANTITY A T N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	05-10887	9	Spacer, LED, 1/4" tall	Richco #LEDS 2-4-26	
2	80-00022	1	22AWG Buss Wire	1BB-2201 ANIXTER	
4	04-11033	1	LED Mounting Jig	DWG 2330-216	
A1	04-30287	1	Display PCB	DWG 2330-702	
C3	02-20024	1	22pF,500V,MICA	CM04ED220J03	
C4	02-20024	1	22pF,500V,MICA	CM04ED220J03	
C8	02-40026	1	10u 50V Alum. Radial	ILL. 106RMR050M 20%	
C9	02-40026	1	10u 50V Alum. Radial	ILL. 106RMR050M 20%	
C11	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C12	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C13	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C14	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C15	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C16	02-40026	1	10u 50V Alum. Radial	ILL. 106RMR050M 20%	
D1	03-20000	1	Diode, general purpose	1N4148 or 1N914	
D2	03-20000	1	Diode, general purpose	1N4148 or 1N914	
D3	03-20000	1	Diode, general purpose	1N4148 or 1N914	
D4	03-20000	1	Diode, general purpose	1N4148 or 1N914	
LD3	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD5	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD7	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD8	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD9	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD10	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD11	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD12	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD13	05-01042	1	LED, Red, 5V, Large	P-tec PL60-CD-H	
LD17	05-01013	1	LED,Green,Panel Mount	Hewlett Packard,5082-4955	
P3	05-10881	1	Wafer, 3 pin Locking, 0.1" Spacing, Gold	Molex 22-11-2032	
P4	08-10044	1	Keyboard to Display Cable	ASSY 2330-057	
P7	08-10042	1	CPU to Display Bd Cable	ASSY 2330-055	
P8	08-10043	1	Display to VFD Cable	ASSY 2330-056	
PB1	05-03118	1	Switch, Push button, Momentary, PCB mtg.	ITT Schadow KSL-A-1-M-Ag	
Q1	03-10026	1	N-Channel VMOS (TO92)	VN10KM	
R1	01-01119	1	10M 5% 1/4W Carbon Film	RC07GF106J	
R2	01-01037	1	680 5% 1/4W Carbon Film	RC07GF681J	
R3	01-01041	1	1K 5% 1/4W Carbon Film	RC07GF102J	
R4	01-01041	1	1K 5% 1/4W Carbon Film	RC07GF102J	
R5	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R7	01-01015	1	47 5% 1/4W Carbon Film	RC07GF470J	
R8	01-01033	1	470 5% 1/4W Carbon Film	RC07GF471J	
R9	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R10	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R11	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R14	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R15	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R16	01-01050	1	3.3K 5% 1/4W Carbon Film	RC07GF332J	
R17	01-01021	1	100 5% 1/4W Carbon Film	RC07GF101J	
R18	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R19	01-01041	1	1K 5% 1/4W Carbon Film	RC07GF102J	
R20	01-01105	1	2.2M 5% 1/4W Carbon Film	RC07GF225J	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R21	01-01021	1			100 5% 1/4W Carbon Film	RC07GF101J	
R22	01-01021	1			100 5% 1/4W Carbon Film	RC07GF101J	
R23	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R24	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
RN1	01-40014	1			9 x 100K Network (SIP)	A-B 110A-104	
RP1	01-40032	1			8 x 4.7K Network	A-B 316B-472	
SKR1	05-10988	1			Piezo Beeper, 5V, Self Oscillating	Sonicall #SM-13P-7.5	
U2	03-30631	1			LED Driver	MC14489P	
U3	03-30632	1			Quad 2 input NAND Gate	MC74HC00N	
U5	03-50129	1			Display Microprocessor	DWG 2330-902 using 03-30630	
U6	03-30633	1			Hex Schmitt-Trigger Inverter	74HC14N	
U7	03-30635	1			Under Voltage Sensor	MC34064P	
U8	03-30634	1			Octal Latch	MC74HC573N	
X1	05-02025	1			Crystal, 2.4576 Mhz	HC18-2.4576Mhz-0.005%	
XU5	05-10246	1			Socket, dil, 40 pin	Burndy DILB40P-11	

REF.DES.	STOCK #	QUANTITY A T N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	80-00016	1	16AWG Buss Wire	Anixter 1BB-1601	
2	05-10488	4	Shorting plug, .1 spacing, gold	Molex 15-29-1024	
A1	04-30289	1	Microprocessor Board	DWG 2330-704	
C101	02-40030	1	220uF 16V Alum. Radial	Illinois 227RS0M016M	
C102	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C201	02-10017	1	0.022uF 5% 50V Ceramic Dipped	Kemet C320C223J5R5CA	
C202	02-10017	1	0.022uF 5% 50V Ceramic Dipped	Kemet C320C223J5R5CA	
C203	02-10017	1	0.022uF 5% 50V Ceramic Dipped	Kemet C320C223J5R5CA	
C204	02-10017	1	0.022uF 5% 50V Ceramic Dipped	Kemet C320C223J5R5CA	
C205	02-10017	1	0.022uF 5% 50V Ceramic Dipped	Kemet C320C223J5R5CA	
C206	02-10017	1	0.022uF 5% 50V Ceramic Dipped	Kemet C320C223J5R5CA	
C207	02-10017	1	0.022uF 5% 50V Ceramic Dipped	Kemet C320C223J5R5CA	
C208	02-10017	1	0.022uF 5% 50V Ceramic Dipped	Kemet C320C223J5R5CA	
C209	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C210	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C211	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C212	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C213	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C214	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C215	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C216	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C217	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C218	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C219	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C220	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C221	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C222	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C223	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C224	02-60014	1	0.01uF,100V,Mylar,5%	WIMA MKC2-0.01uF	
C301	02-20024	1	22pF,500V,MICA	CM04ED220J03	
C302	02-20024	1	22pF,500V,MICA	CM04ED220J03	
C303	02-30004	1	1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C304	02-30001	1	10uF 25V Tantalum Bead	AVX TAP106K025SP	
C305	02-30004	1	1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C306	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C307	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C308	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C309	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C310	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C311	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C312	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C313	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C314	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C315	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C401	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C402	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C403	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C404	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C405	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C406	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C407	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
C408	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C501	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C502	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C505	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C506	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C601	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C602	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C603	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C606	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C607	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C701	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C702	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C703	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C704	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C705	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C706	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C707	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C708	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C709	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C710	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C711	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C712	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C713	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C801	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C802	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C803	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C804	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C805	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C806	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C901	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C902	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C903	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C904	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C1001	02-40030	1			220uF 16V Alum. Radial	Illinois 227RS0M016M	
C1002	02-40030	1			220uF 16V Alum. Radial	Illinois 227RS0M016M	
C1003	02-40030	1			220uF 16V Alum. Radial	Illinois 227RS0M016M	
D301	03-20000	1			Diode, general purpose	1N4148 or 1N914	
D302	03-20000	1			Diode, general purpose	1N4148 or 1N914	
DS301	05-01040	1			Integrated Resistor Lamp, 5V, Red	Hewlett Packard HLMP-3600	
DS302	05-01040	1			Integrated Resistor Lamp, 5V, Red	Hewlett Packard HLMP-3600	
DS303	05-01040	1			Integrated Resistor Lamp, 5V, Red	Hewlett Packard HLMP-3600	
DS304	05-01040	1			Integrated Resistor Lamp, 5V, Red	Hewlett Packard HLMP-3600	
DS701	05-01039	1			Integrated Resistor Lamp, 5V, Green	Hewlett Packard HLMP-3680	
J201	05-10585	1			Connector,10 pin,0.1x0.1,with lock	Robinson Nugent IDH-10K-S3-TG-EL-1K	
J202	08-10038	1			CPU to Mother Bd Cable	ASSY 2330-051	
J203	08-10038	1			CPU to Mother Bd Cable	ASSY 2330-051	
J204	08-10038	1			CPU to Mother Bd Cable	ASSY 2330-051	
J205	05-10831	1			Connector, 26 pin, .1x.1sp, Locking	ROBINSON-NUGENT IDH-26K-S3-TG-EL-1K	
J206	05-10585	1			Connector,10 pin,0.1x0.1,with lock	Robinson Nugent IDH-10K-S3-TG-EL-1K	
J207	05-10978	1			Header, 24 pin, Lock & Eject, .1 x .1 sp	T&B Ansley 609-2427C	
J210	05-10716	1			Header,10pin (.1 x.1) pcb mount	Ansley 609-1027	

REF.DES.	STOCK #	QUANTITY A T N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
JP301	05-10529	1	Header, 3 pin, .56 lg, gold, .10 sp.	Molex 22-10-2031	
JP501	05-10529	1	Header, 3 pin, .56 lg, gold, .10 sp.	Molex 22-10-2031	
JP801	05-10529	1	Header, 3 pin, .56 lg, gold, .10 sp.	Molex 22-10-2031	
JP802	05-10529	1	Header, 3 pin, .56 lg, gold, .10 sp.	Molex 22-10-2031	
P101	05-10877	1	Header, 2 pin, Locking, 0.156 sp.	Molex 26-61-4020	
R201	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R202	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R203	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R204	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R205	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R206	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R207	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R208	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R209	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R210	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R211	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R212	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R213	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R214	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R215	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R216	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R217	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R218	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R219	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R220	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R221	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R222	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R223	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R224	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R225	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R226	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R227	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R228	01-10279	1	402 1% 50ppm/C 1/4W Metal Film	RN60C4020F	
R229	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R230	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R231	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R232	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R233	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R301	01-01041	1	1K 5% 1/4W Carbon Film	RC07GF102J	
R302	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R303	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R304	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R305	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R306	01-01053	1	4.7K 5% 1/4W Carbon Film	RC07GF472J	
R307	01-01053	1	4.7K 5% 1/4W Carbon Film	RC07GF472J	
R308	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R309	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R310	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R312	01-01133	1	10M 5% 1/4W Carbon Film	A86-0185	
R313	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	
R314	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	

REF.DES.	STOCK #	QUANTITY A	QUANTITY T	QUANTITY N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R315	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R316	01-01068	1			27K 5% 1/4W Carbon Film	RC07GF273J	
R317	01-01125	1			11K 5% 1/4W Carbon Film	RC07GF113J	
R318	01-01021	1			100 5% 1/4W Carbon Film	RC07GF101J	
R501	01-01053	1			4.7K 5% 1/4W Carbon Film	RC07GF472J	
R502	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R601	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R705	01-10047	1			49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	
R706	01-10047	1			49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	
R801	01-01046	1			2.2K 5% 1/4W Carbon Film	RC07GF222J	
R802	01-01046	1			2.2K 5% 1/4W Carbon Film	RC07GF222J	
R803	01-01046	1			2.2K 5% 1/4W Carbon Film	RC07GF222J	
R901	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R902	01-01046	1			2.2K 5% 1/4W Carbon Film	RC07GF222J	
R903	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R1001	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
RN301	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN302	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN401	01-40031	1			9 x 4.7K Network (SIP)	BI L10-IC472	
RN402	01-40031	1			9 x 4.7K Network (SIP)	BI L10-IC472	
RN403	01-40031	1			9 x 4.7K Network (SIP)	BI L10-IC472	
RN404	01-40031	1			9 x 4.7K Network (SIP)	BI L10-IC472	
RN405	01-40031	1			9 x 4.7K Network (SIP)	BI L10-IC472	
RN406	01-40016	1			9 x 2.2K Network (SIP)	A-B 110A-222	
RN701	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN702	01-40015	1			9 x 10K Network (SIP)	A-B 110A-103	
RN801	01-40031	1			9 x 4.7K Network (SIP)	BI L10-IC472	
RN1001	01-40031	1			9 x 4.7K Network (SIP)	BI L10-IC472	
RN1002	01-40031	1			9 x 4.7K Network (SIP)	BI L10-IC472	
S401	05-03096	1			Switch, DIL, 8 position	Grayhill #76SB08	
TP101	05-10290	1			Test Hook, PCB	Vector K32-2	
TP102	05-10290	1			Test Hook, PCB	Vector K32-2	
U301	03-30607	1			Quad 2 Input OR Gate	74ACT32	
U302	03-30612	1			Syncronous 4-Bit Decade and Binary Counter	74ALS161	
U303	03-30639	1			Precision Voltage Monitor	Maxim MAX695CPE	
U304	03-30615	1			Octal D-Type F/F W/3 State Output	74ACT574	
U305	03-30617	1			Octal Bus Driver	74ACT244	
U306	03-30607	1			Quad 2 Input OR Gate	74ACT32	
U307	03-30606	1			Hex Inverter	74ACT04	
U308	03-30628	1			Microprocessor	Motorola XC68HC11K1CFN4	
U309	03-30605	1			Octal Bus Transceiver	74ACT245	
U310	03-30612	1			Syncronous 4-Bit Decade and Binary Counter	74ALS161	
U401	03-30615	1			Octal D-Type F/F W/3 State Output	74ACT574	
U402	03-30607	1			Quad 2 Input OR Gate	74ACT32	
U403	03-30621	1			8 to 3 Line Encoder	74HCT148	
U404	03-30623	1			4 to 6 Line Decoder / Demultiplexer	Texas Instruments SN74HC154-NT	
U405	03-30617	1			Octal Bus Driver	74ACT244	
U406	03-30617	1			Octal Bus Driver	74ACT244	
U501	03-50127		1		2330A Operating 1	DWG 2330-900 using 03-30625	
U502	03-50128		1		2330A Operating 2	DWG 2330-901 using 03-30528	
U601	03-30608	1			2K x 8 Zero Power/Time Keeper RAM	48T02B-15	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
U602	03-30607	1			Quad 2 Input OR Gate	74ACT32	
U604	03-30618	1			32K x 8 CMOS Static RAM	D43256C-15L	
U701	03-30615	1			Octal D-Type F/F W/3 State Output	74ACT574	
U702	03-30615	1			Octal D-Type F/F W/3 State Output	74ACT574	
U703	03-30624	1			20 Bit A/D Converter	Crystal CS5506-BP	
U704	03-30624	1			20 Bit A/D Converter	Crystal CS5506-BP	
U705	03-30624	1			20 Bit A/D Converter	Crystal CS5506-BP	
U706	03-30624	1			20 Bit A/D Converter	Crystal CS5506-BP	
U707	03-30626	1			Analog Multiplexer / Demultiplexer with Latch	Harris 74HC4352	
U708	03-30629	1			Precision Reference	LT1019ACN8-2.5	
U801	03-30337	1			Hex Schmitt Inverter	74LS14	
U802	03-30652	1			Dual Asynchronous Communication Element	TI TL16C552FN	
U803	03-30610	1			+5V Powered RS-232 Driver/Reciever	MAX233	
U901	03-30615	1			Octal D-Type F/F W/3 State Output	74ACT574	
U902	03-30611	1			Octal Gen. Purpose Interface Bus Transceiver	75ALS160	
U903	03-30620	1			Octal Gen. Purpose Interface	75ALS162	
U904	03-30607	1			Quad 2 Input OR Gate	74ACT32	
U905	03-30605	1			Octal Bus Transceiver	74ACT245	
U906	03-30471	1			GPIB Controller to MPU Interface	TMS9914ANL	
U1003	03-30605	1			Octal Bus Transceiver	74ACT245	
U1004	03-30615	1			Octal D-Type F/F W/3 State Output	74ACT574	
XU308	05-10982	1			Socket, 84 pin PLCC	Robinson Nugent PLCCE-084-S1-TT	
XU501	05-10295	1			Socket, dil, 28 pin	Burndy DILB28P-108	
XU502	05-10295	1			Socket, dil, 28 pin	Burndy DILB28P-108	
XU802	05-10596	1			68-pin PLCC Socket	Burndy QILE-68P-410T	
Y301	05-02024	1			Crystal, 16Mhz	Fox 160	
Y701	05-02023	1			Oscillator, 32.768kHz	Statek LXO-32.768kHz-A-I	

REF.DES.	STOCK #	QUANTITY A T N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	05-10838	8	Heatsink, TO-220, Black Anodize	AAVID #576802B04000	
2	05-10903	1	Heatsink, Wave Solder, 1" High (TO-3) .062 Bd	AAVID 568203B00600	
3	96-00043	2	#6-32 x 9/16" Phil Pan Zinc Plated		
4	98-06002	2	#6 Internal Star Washer, S.S.		
5	05-10850	1	Heatsink, Expandable Collar (TO-3)	Aavid 579103-C00000	
6	05-10869	1	Insulator, TO-3	Berquist QII-29	05-10232
8	80-02218	8	18awg Wire, Red TFE	M16878/4-BHE-2	
9	80-02018	8	18awg Wire, Black TFE	M16878/4-BHE-0	
10	05-10693	1	Conn. Housing, 2 Pin, Locking, 0.156 SP.	Molex 09-50-8023	
11	05-10301	2	Crimp Terminal 0.156 sp. housing, 18-24 AWG	Molex 08-50-0106	
12	98-04002	6	#4 Internal Star Washer S.S.		
13	90-04006	6	#4-40 x 3/8" Phil Pan S.S.		
14	97-04001	6	#4-40 Radio Hex Nut S.S.		
15	80-00020	1	20AWG Buss Wire		
17	05-10582	1	Cable Tie 8.0"lg x .10"wide	Panduit PLT2M	
18	80-00022	1	22AWG Buss Wire	1BB-2201 ANIXTER	
19	70-11022	1	22AWG TFE Sleeving	ATC TFT 22	
A1	04-30286	1	Mother Board	DWG 2330-701	
C102	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C103	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C104	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C105	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C106	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C107	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C108	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C109	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C110	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C111	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C112	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C113	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C114	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C115	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C116	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C117	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C118	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C119	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C120	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C121	02-60000	1	.0047uF 100V Mylar	Illinois 472SHR100K59CE	
C122	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C123	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C124	02-40013	1	470uF 50V Aluminum	Illinois 477TTA050	
C125	02-40013	1	470uF 50V Aluminum	Illinois 477TTA050	
C126	02-30004	1	1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C127	02-30004	1	1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C128	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C129	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C130	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C131	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C132	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C133	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C134	02-10014	1	0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
C135	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C136	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C137	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C138	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C139	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C140	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C141	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C142	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C143	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C501	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C502	02-40013	1			470uF 50V Aluminum	Illinois 477TTA050	
C503	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C504	02-30004	1			1uF 25V Tantalum Bead	Kemet T350A105K025AS	
C505	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C506	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C511	02-40012	1			15000uF 16V Aluminum	Illinois 159TTA016	
C512	02-30014	1			100u 10V Tantalum Bead	AVX TAP106K025SP	
C521	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C524	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
C525	02-10014	1			0.1uF 50V Ceramic Disc	AVX SR205E104MAA00	
CR113	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR114	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR501	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR502	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR503	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR504	03-20090	1			Diode, Rectifier, 1.1A, 60V Schottkey	I.R. 11DQ06	
CR505	03-20091	1			Rectifier, Schottky, 9A, 35V	IR 90SQ035	
CR506	03-20091	1			Rectifier, Schottky, 9A, 35V	IR 90SQ035	
IC102	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC103	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC104	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC106	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC107	03-30090	1			General Purpose JFET Op-Amp	LF356N or H	03-30074
IC108	03-30036	1			Regulator,+15V,0.5A,TO202 or TO220	78M15CP or LM340T-15	
IC109	03-30037	1			Regulator,-15V,0.5A,TO202 or TO220	79M15CP or LM320T-15	
IC110	03-30049	1			UNKNOWN PART		
IC111	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC112	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC113	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC114	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC115	03-30170	1			Low Noise, low drift Op-amp	OP07DP	
IC116	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC117	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC118	03-30314	1			Dual 2 to 1 JFET Analog Switch	DG303A	
IC310	03-30449	1			10v Pretrimmed Volt. Ref.	Anal Dev AD581JH	
IC501	03-30036	1			Regulator,+15V,0.5A,TO202 or TO220	78M15CP or LM340T-15	
IC502	03-30037	1			Regulator,-15V,0.5A,TO202 or TO220	79M15CP or LM320T-15	
IC503	03-30649	1			2-Serial, 1 Parallel Port (ACE)	TI TL16C452FN	
IC509	03-30095	1			Dual D-Type Flip Flop	74LS74N or 74ALS74N (ALT 03-30338)	
IC510	03-30095	1			Dual D-Type Flip Flop	74LS74N or 74ALS74N (ALT 03-30338)	
IC511	03-30085	1			Regulator,+8V,0.5A,TO202 or TO220	78M08CP or LM340T-8.0	

REF.DES.	STOCK #	QUANTITY A T N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
IC512	03-30173	1	Hex inverter open collector (30V)	7406	
IC513	03-30173	1	Hex inverter open collector (30V)	7406	
J2	05-10729	1	2734 Regulator/Power Supply Cable	DWG 2734-056	
J4	05-10729	1	2734 Regulator/Power Supply Cable	DWG 2734-056	
PL101	05-10586	1	64 pin DIN Socket, PCB Mtg (3 row)	ELCO 20-8457-096-002-026	
PL503	05-10898	1	Header, 12pin, 0.1"sp, Locking	Molex 22-11-2122	
PL504	05-10817	1	Header, 2 Pin, Straight, .1"sp, Gold, Locking	Molex 22-11-2022	
PL505	05-10817	1	Header, 2 Pin, Straight, .1"sp, Gold, Locking	Molex 22-11-2022	
PL508	05-10729	1	2734 Regulator/Power Supply Cable	DWG 2734-056	
R104	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R106	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R107	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R108	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R109	01-10001	1	1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R113	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R114	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R115	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R116	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R117	01-10001	1	1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R121	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R122	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R123	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R124	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R125	01-10001	1	1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R129	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R130	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R131	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R132	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R133	01-10001	1	1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R136	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R137	01-10047	1	49.9K 1% 50ppm/C 1/4W Metal Film	RN60C4992F	
R138	01-10006	1	100K 1% 50ppm/C 1/4W Metal Film	RN60C1003F	
R139	01-10111	1	1.24M 1% 50ppm/C 1/4W Metal Film	RN60C1244F	
R140	01-10001	1	1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R141	01-20149	1	1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R142	01-20177	1	500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R143	01-20149	1	1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R144	01-20177	1	500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R145	01-10188	1	133 1% 5ppm/C 1/8W Metal Film	PRP 1/8W - 133OHM - 1% - 5PPM	
R146	01-20149	1	1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R148	01-20177	1	500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R149	01-20149	1	1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R151	01-20149	1	1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R152	01-20177	1	500 0.1% 5ppm/C Wirewound	GS602-500R-0.1%-5ppm	
R153	01-20149	1	1K .05% 5ppm/C Wire Wound	Goldstar GS602-1K-.05%-5ppm	
R154	01-10026	1	374 1% 50ppm/C 1/4W Metal Film	RN60C3740F	
R155	01-01054	1	5.1K 5% 1/4W Carbon Film	RC07GF512J	
R156	01-01054	1	5.1K 5% 1/4W Carbon Film	RC07GF512J	
R157	01-01054	1	5.1K 5% 1/4W Carbon Film	RC07GF512J	
R159	01-01054	1	5.1K 5% 1/4W Carbon Film	RC07GF512J	
R517	01-01061	1	10K 5% 1/4W Carbon Film	RC07GF103J	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
R518	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R519	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R520	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R521	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R522	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R523	01-01043	1			1.5K 5% 1/4W Carbon Film	RC07GF152J	
R524	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R525	01-01043	1			1.5K 5% 1/4W Carbon Film	RC07GF152J	
R526	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R527	01-01043	1			1.5K 5% 1/4W Carbon Film	RC07GF152J	
R528	01-01061	1			10K 5% 1/4W Carbon Film	RC07GF103J	
R529	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R530	01-01041	1			1K 5% 1/4W Carbon Film	RC07GF102J	
R533	01-10282	1			121 1% 50ppm/C 1/2W Metal Film	RN60C1210F	
R534	01-10173	1			365 1% 50ppm/C 1/4W Metal Film	RN60C3650F	
R535	01-10323	1			6.04K 0.1% 5ppm/C 1/8W Metal Film	PRP 1/8W 6.04K 0.1% 5PPM	
R536	01-10379	1			2.80K .1% 5ppm/C 1/8W Metal Film	PRP 1/8W 2.80K .1% 5PPM	
R537	01-10353	1			3.01K 0.1% 5ppm/C Metal Film	PRP 1/4W 3.01K 0.1% 5PPM	
R538	01-10323	1			6.04K 0.1% 5ppm/C 1/8W Metal Film	PRP 1/8W 6.04K 0.1% 5PPM	
R539	01-10323	1			6.04K 0.1% 5ppm/C 1/8W Metal Film	PRP 1/8W 6.04K 0.1% 5PPM	
RV101	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV102	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV103	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV104	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV105	01-50028	1			50K Top Adjust	Beckman 68WR50K	
RV106	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV107	01-50018	1			10 Top Adjust	Beckman 68WR10ohm	
RV108	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV109	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV110	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
RV111	01-50033	1			50 Top Adjust	Beckman 68WR50ohm	
T101	04-20086	1			Power Transformer Dual 18V	Signal DST-5-36	
T501	04-20086	1			Power Transformer Dual 18V	Signal DST-5-36	
T502	04-20040	1			Power XFMR	Signal,DPC-12-2000	
TP101	05-10290	1			Test Hook, PCB	Vector K32-2	
TP102	05-10290	1			Test Hook, PCB	Vector K32-2	
TP103	05-10290	1			Test Hook, PCB	Vector K32-2	
TP104	05-10290	1			Test Hook, PCB	Vector K32-2	
TP105	05-10290	1			Test Hook, PCB	Vector K32-2	
TP106	05-10290	1			Test Hook, PCB	Vector K32-2	
TP107	05-10290	1			Test Hook, PCB	Vector K32-2	
TP501	05-10290	1			Test Hook, PCB	Vector K32-2	
TP502	05-10290	1			Test Hook, PCB	Vector K32-2	

REF.DES.	STOCK #	QUANTITY A	T	N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
1	05-10922	1			12 pin Housing, .1"sp, Locking, Polarizing	Molex 22-01-3127	
2	05-10340	12			Crimp Terminal for 0.1" Housings, Gold, 22AWG	Molex 08-55-0102	
3	05-10019	11			Cable tie, 4"x 1/8"	Panduit WRN-4	
4	80-02422	18			22awg Wire, Yellow TFE	M16878/4-BFE-4	
5	80-02922	137			22AWG Wire, White TFE	M16878/4-BFE-9	
6	80-02122	18			22AWG Wire, Brown TFE	M16878/4-BFE-1	
7	80-02322	18			22AWG Wire, Orange TFE	M16878/4-BFE-3	
8	80-02222	9			22AWG Wire, Red TFE	M16878/4-BFE-2	
9	80-02822	9			22AWG Wire, Gray TFE	M16878/4-BFE-8	
10	80-02022	119			22AWG Wire, Black TFE	M16878/4-BFE-0	
11	70-00002	17			1/8" Black Shrink Tubing FP301	3M 3000125BK	
12	05-10786	4			Standoff,1/4"dia,1.25"lg,6-32,M-F	Smith 9080S	
13	98-06002	4			#6 Internal Star Washer, S.S.		
14	90-06005	4			#6-32 x 5/16" Phil Pan S.S.		
15	05-10254	1			Connector, male, 25 way, D	Cannon DBE25P	
16	97-06000	4			#6-32 Standard Hex Nut, S.S.		
18	98-06001	4			#6 Split Lock Washer,STD,S.S.		
19	99-99009		1		THREADLOCK MEDIUM	Loctite 222	
20	05-10986		1		Jacksocket Assembly for .125 thk panel #4-40	T&B 609-007-1	
A1	04-30095	1			2300 "IOX" Analog Output Board	DWG 2300-703	
C1	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
C2	02-30001	1			10uF 25V Tantalum Bead	AVX TAP106K025SP	
IC1	03-30322	1			Dual General Purpose JFET Op Amp	LF353N	
IC2	03-30322	1			Dual General Purpose JFET Op Amp	LF353N	
IC3	03-30322	1			Dual General Purpose JFET Op Amp	LF353N	
IC4	03-30322	1			Dual General Purpose JFET Op Amp	LF353N	
IC5	03-30322	1			Dual General Purpose JFET Op Amp	LF353N	
IC6	03-30322	1			Dual General Purpose JFET Op Amp	LF353N	
R1	01-10103	1			900 0.1% 50ppm/C 1/4W Metal Film	RN60C9000B	
R2	01-10103	1			900 0.1% 50ppm/C 1/4W Metal Film	RN60C9000B	
R3	01-10001	1			1.0K 1% 50ppm/C 1/4W Metal Film	RN60C1001F	
R4	01-10127	1			806 1% 50ppm/C 1/4W Metal Film	RN60C8060F	
R5	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R6	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R7	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R8	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R9	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R10	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R11	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R12	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R13	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R14	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
R15	01-01016	1			56 5% 1/4W Carbon Film	RC07GF560J	
RN1	01-40013	1			8 x 10K Network	A-B 316B-103	
RN2	01-40007	1			15 x 100 Network	A-B 316A-101	
RN3	01-40013	1			8 x 10K Network	A-B 316B-103	
RN4	01-40008	1			8 x 1K Network	A-B 316B-102	
RN5	01-40008	1			8 x 1K Network	A-B 316B-102	
RN6	01-40008	1			8 x 1K Network	A-B 316B-102	
RV1	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV2	01-50035	1			50K End Adjust	Beckman 89PR50K	

REF.DES.	STOCK #	QUANTITY A	QUANTITY T	QUANTITY N	DESCRIPTION	MANUFACTURING/PURCHASING DATA	ALTERNATE
RV3	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV4	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV5	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV6	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV7	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV8	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV9	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV10	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV11	01-50035	1			50K End Adjust	Beckman 89PR50K	
RV12	01-50043	1			200 End Adjust	Beckman 89PR200ohm	
RV13	01-50043	1			200 End Adjust	Beckman 89PR200ohm	
RV14	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV15	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV16	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV17	01-50043	1			200 End Adjust	Beckman 89PR200ohm	
RV18	01-50043	1			200 End Adjust	Beckman 89PR200ohm	
RV19	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV20	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV21	01-50043	1			200 End Adjust	Beckman 89PR200ohm	
RV22	01-50043	1			200 End Adjust	Beckman 89PR200ohm	
RV23	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV24	01-50017	1			500 End Adjust	Beckman 89PR500ohm	
RV25	01-50017	1			500 End Adjust	Beckman 89PR500ohm	

SECTION XIV DRAWINGS AND SCHEMATICS

The following drawings have been included in this manual:

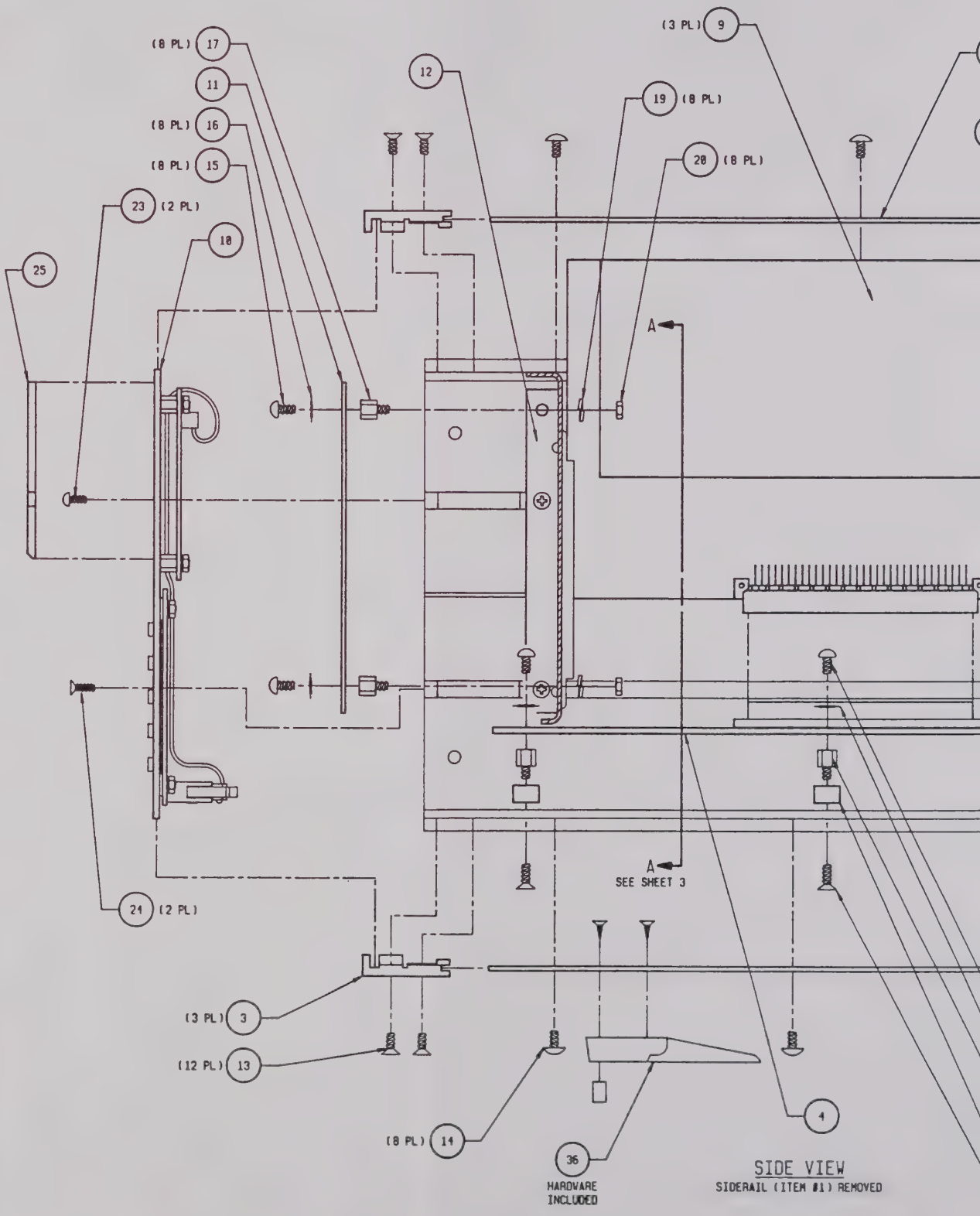
2330/01 Chassis Assembly 2330-400
2330/01 Signal Processing Board Schematic 2330-070
2330/01 Signal Processing Board Assembly 2330-600
2330 Main PCB Schematic 2330-071
2330 Main PCB Assembly 2330-601
2330 Display PCB Schematic 2330-072
2330 Display PCB Assembly 2330-602
2330 Microprocessor Board Schematic. 2330-074
2330 Microprocessor Board Assembly 2330-604

Option IOX Assembly 2330-403
Option IOX Schematic 2330-076

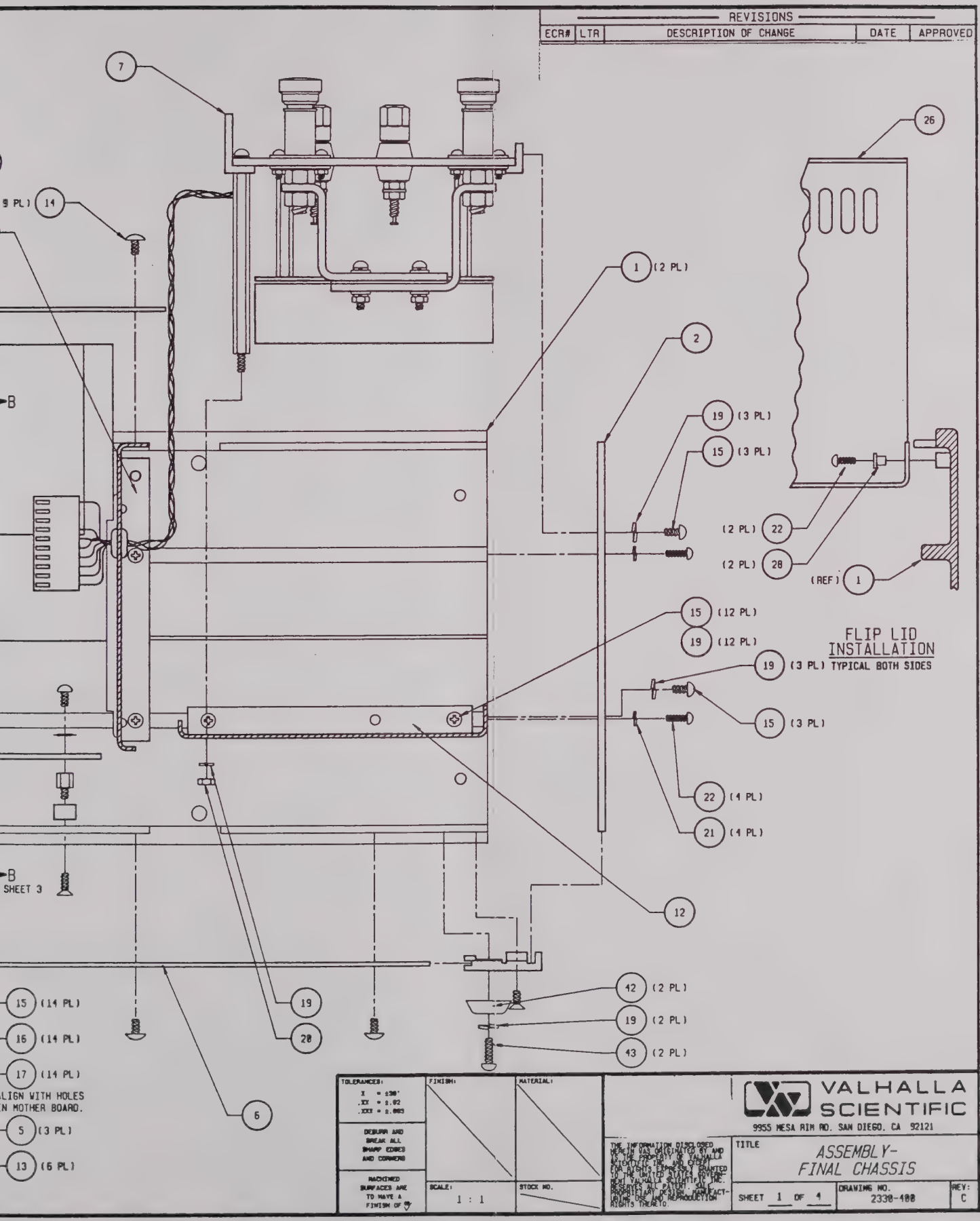
2330-01 Main PCB Assembly 2330-608

NOTES: Unless Otherwise Specified

1. SEE SEPARATE PARTS LIST.
2. FOR ALL WIRING SEE SHEET 3 (INTERCONNECT DIAGRAM).



SIDE VIEW
SIDERAIL (ITEM #1) REMOVED


REVISIONS
ECR# | LTR | DESCRIPTION OF CHANGE | DATE | APPROVED
7
14
1 (2 PL)
2
19 (3 PL)
15 (3 PL)
26
(2 PL) 22
(2 PL) 28
(REF) 1
FLIP LID INSTALLATION
TYPICAL BOTH SIDES
15 (12 PL)
19 (12 PL)
19 (3 PL)
15 (3 PL)
22 (4 PL)
21 (4 PL)
12
B
SHEET 3
15 (14 PL)
16 (14 PL)
17 (14 PL)
ALIGN WITH HOLES
IN MOTHER BOARD.
5 (3 PL)
13 (6 PL)
19
20
6
42 (2 PL)
19 (2 PL)
43 (2 PL)
TOLERANCES:
X = ±30'
.XX = ±.02
.XXX = ±.005
FINISH:
MATERIAL:
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS
MACHINED SURFACES ARE TO HAVE A FINISH OF
SCALE: 1 : 1
STOCK NO.
VALHALLA SCIENTIFIC
9955 MESA RIM RD. SAN DIEGO, CA 92121
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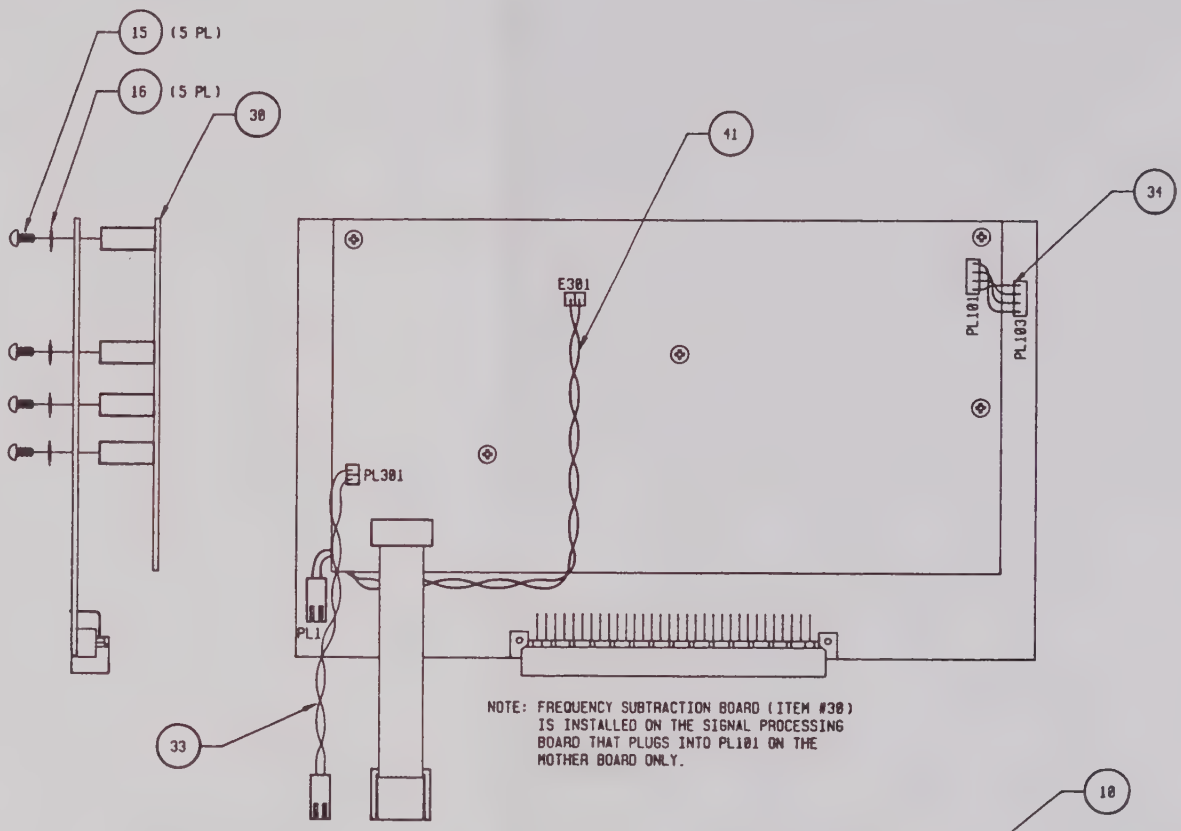
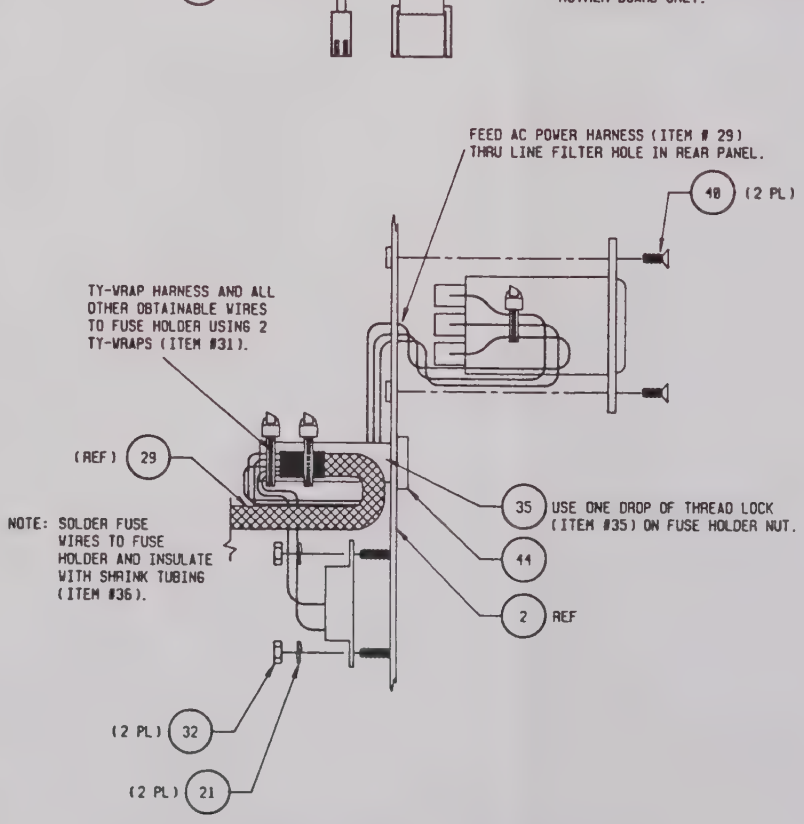
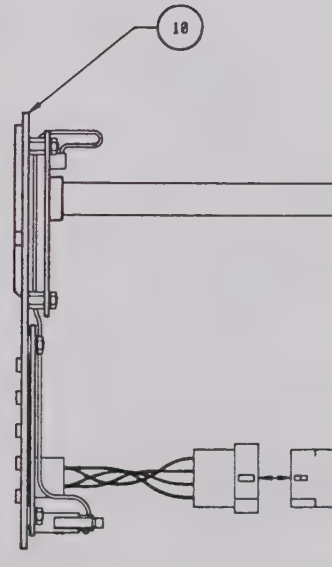
TITLE
ASSEMBLY-
FINAL CHASSIS
SHEET 1 OF 4
DRAWING NO. 2330-100
REV: C

NOTES: Unless Otherwise Specified



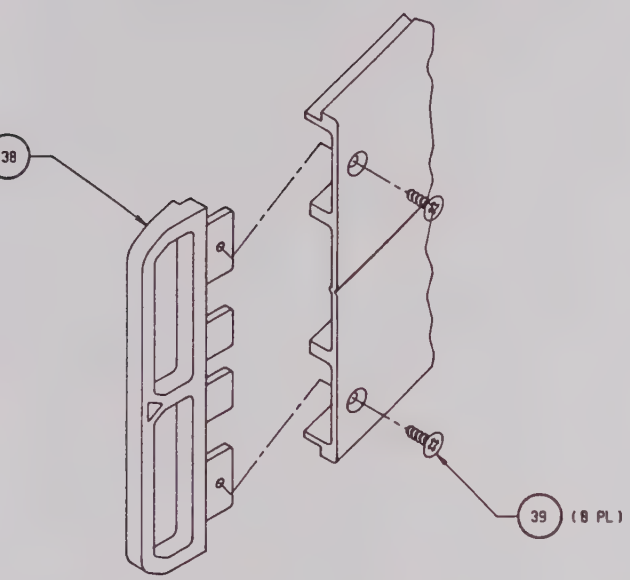

FEED AC POWER HARNESS (ITEM # 29) THRU LINE FILTER HOLE IN REAR PANEL.
40 (2 PL)
TY-WRAP HARNESS AND ALL OTHER OBTAINABLE WIRES TO FUSE HOLDER USING 2 TY-WRAPS (ITEM #31).
(REF) 29
35 USE ONE DROP OF THREAD LOCK (ITEM #35) ON FUSE HOLDER NUT.
NOTE: SOLDER FUSE WIRES TO FUSE HOLDER AND INSULATE WITH SHRINK TUBING (ITEM #36).
44
2 REF
(2 PL) 32
(2 PL) 21

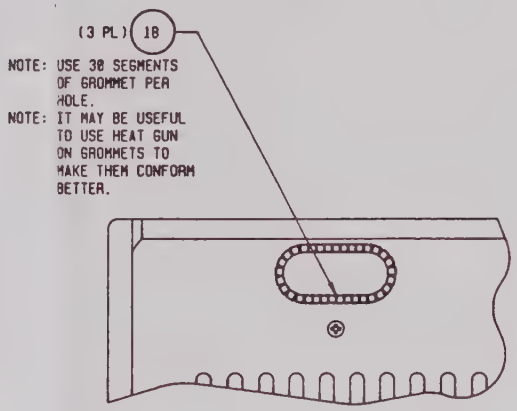


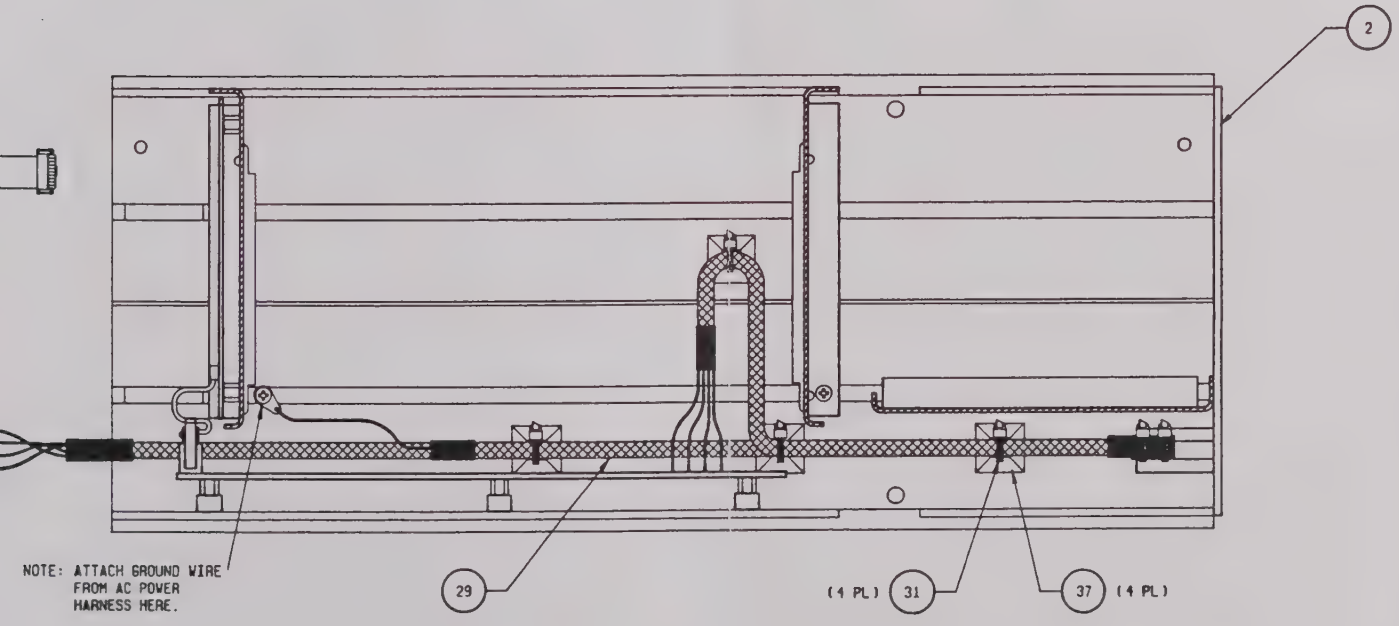
AC POWER HARNESS INSTALLATION

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

SEE SHEET 1 FOR ALL REVISIONS




(3 PL) 18
NOTE: USE 30 SEGMENTS OF GROMMET PER HOLE.
NOTE: IT MAY BE USEFUL TO USE HEAT GUN ON GROMMETS TO MAKE THEM CONFORM BETTER.



TOLERANCES: X = ±.50" .XX = ±.02 .XXX = ±.005	FINISH:	MATERIAL:
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS		
MACHINED SURFACES ARE TO HAVE A FINISH OF	SCALE: 1 : 1	STOCK NO.

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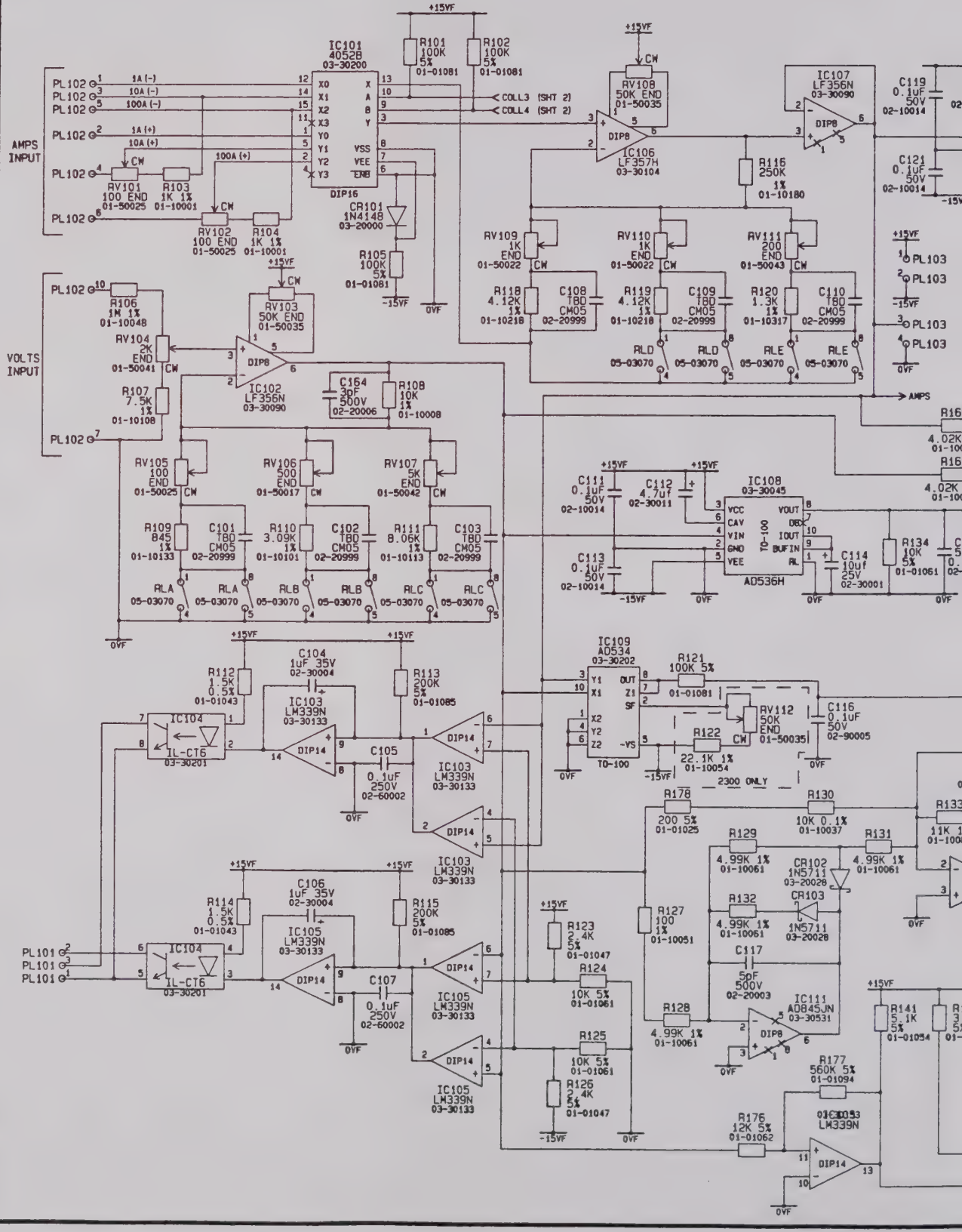
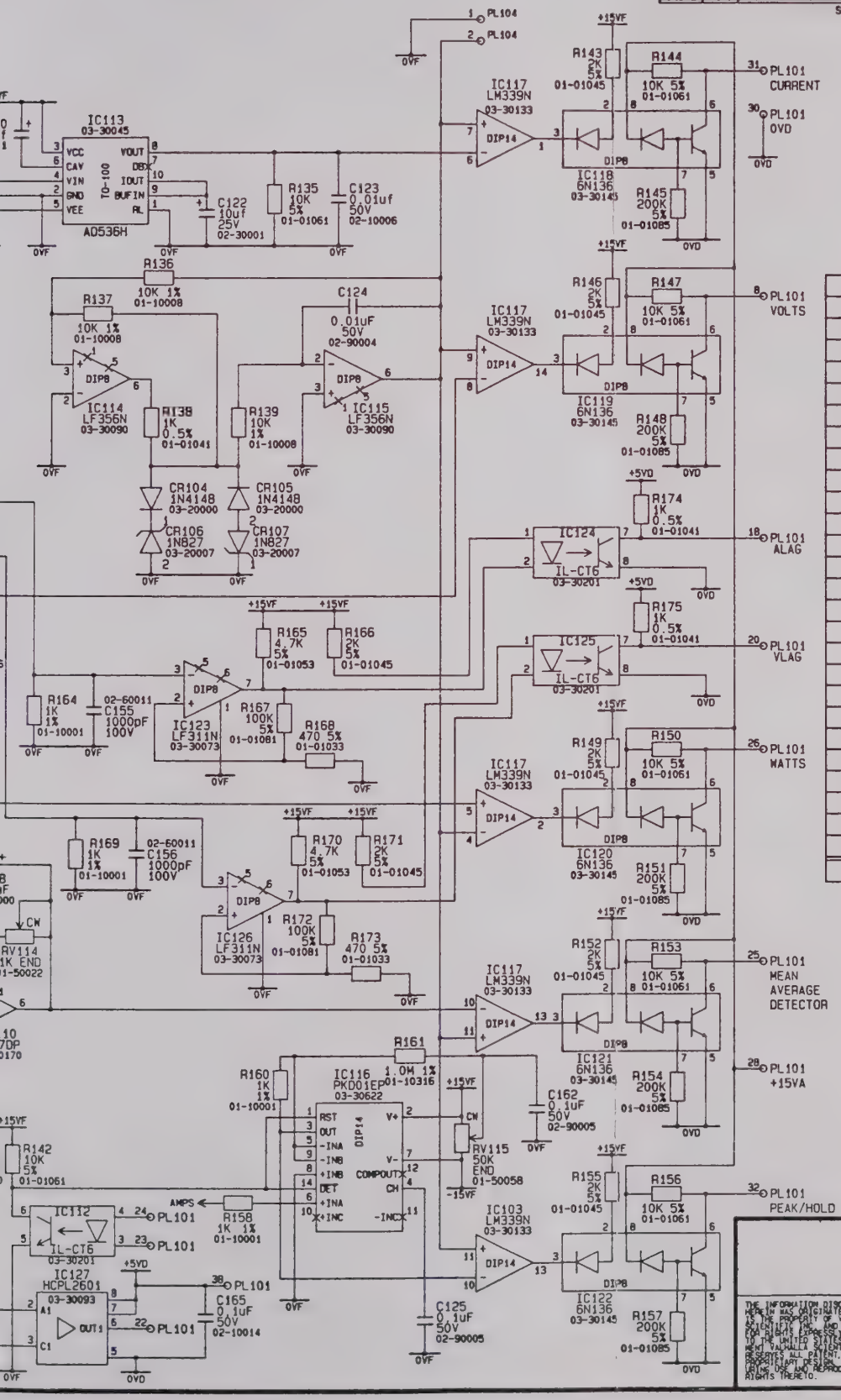
TITLE	SHEET	DRAWING NO.	REV:
ASSEMBLY- FINAL CHASSIS	2 OF 4	2330-100	C

NOTES: Unless Otherwise Specified



REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED
		SEE SHEET 2 FOR ALL REVISIONS		



IC127	——	——	——	DIP8
IC126	8	4	——	DIP8
IC125	——	——	——	DIP8
IC124	——	——	——	DIP8
IC123	8	4	——	DIP8
IC122	8	4	——	DIP8
IC121	——	——	——	DIP8
IC120	——	——	——	DIP8
IC119	——	——	——	DIP8
IC118	——	——	——	DIP8
IC117	3	12	——	DIP14
IC116	SHOWN	SHOWN	13	DIP14
IC115	7	4	——	DIP8
IC114	7	4	——	DIP8
IC113	SHOWN	SHOWN	SHOWN	TO-100
IC112	——	——	——	DIP8
IC111	7	4	——	DIP8
IC110	7	4	——	DIP8
IC109	9	SHOWN	SHOWN	TO-100
IC108	SHOWN	SHOWN	SHOWN	TO-100
IC107	7	4	——	DIP8
IC106	7	4	——	DIP8
IC105	3	12	——	DIP14
IC104	——	——	——	DIP8
IC103	3	12	——	DIP14
IC102	7	4	——	DIP8
IC101	16	——	SHOWN	DIP16
DEVICE	+15VF	-15VF	OVF	DEVICE

PL101	— — — — — —	PL104
RV101	RV113	RV115
RLA	— — — — — —	RLE
R1, R2, R101	R159	R178
IC101	— — — — — —	IC127
CR101	— — — — — —	CR107
C1, C101	— — — — — —	C165
FIRST USED	NOT USED	LAST USED

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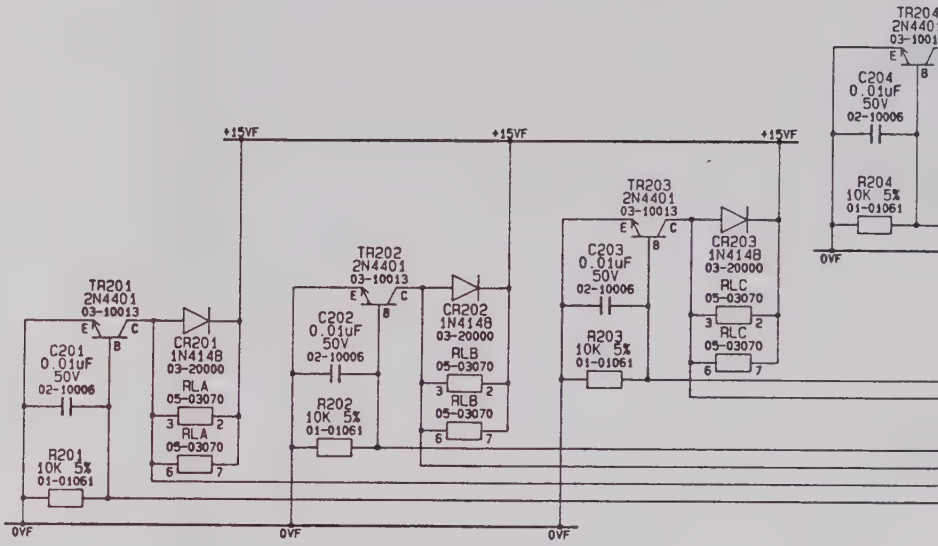
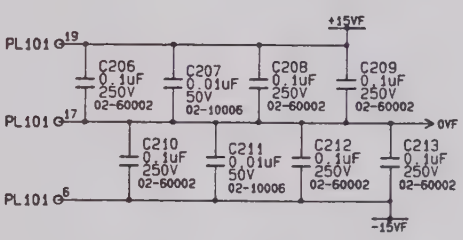
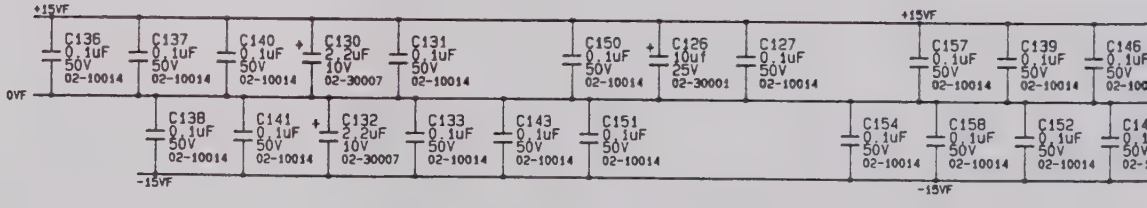
TITLE
SCHEMATIC-
SIGNAL PROCESSING BD.

SHEET 1 OF 2 | DRAWING NO. 2330-070 | REV: F

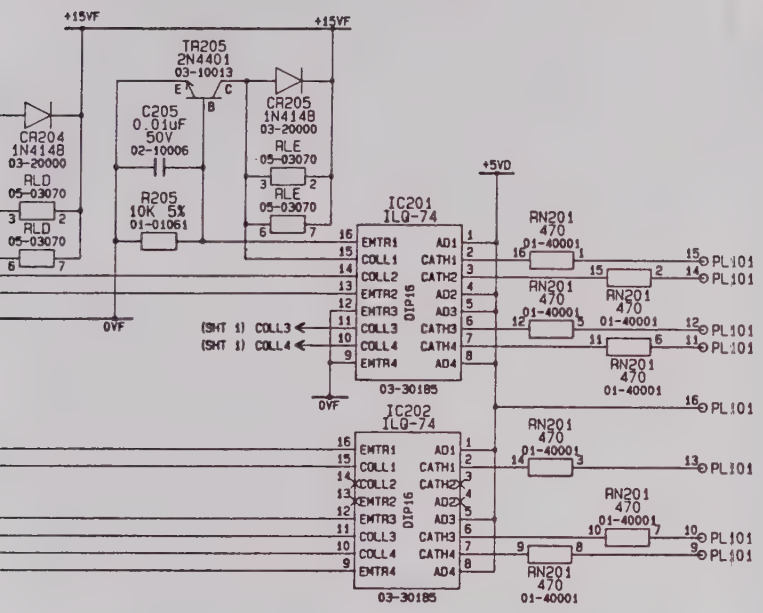
NOTES: Unless Otherwise Specified





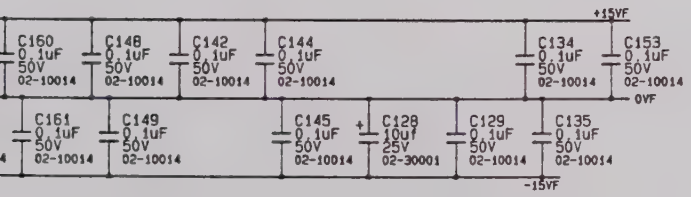


REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



IC202	——	——	——	DIP16
IC201	——	——	——	DIP16
DEVICE	+15VF	-15VF	0VF	PACKAGE

TR201	— — — — —	TR205
RN201	— — — — —	RN201
RLA	— — — — —	RLE
R201	— — — — —	R205
IC201	— — — — —	IC202
CR201	— — — — —	CR205
C201	— — — — —	C213
FIRST USED	NOT USED	LAST USED



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VALHALLA SCIENTIFIC
9955 MESA RIM RD. SAN DIEGO, CA 92121

TITLE
SCHEMATIC-
SIGNAL PROCESSING BD.

SHEET	DRAWING NO.	REV:
2 OF 2	2330-070	F

NOTES: Unless Otherwise Specified

1. SEE SEPARATE PARTS LIST

2. COMPLETELY REMOVE SOLDER FEED THRU AND PAD ON PL102-9 BY DRILLING OUT AND REMOVING SOLDER RING ON COMPONENT AND SOLDER SIDE OF PCB.

3. REMOVE TRACE ON COMPONENT SIDE OF PCB THAT RUNS FROM PL103-2 TO THE FIRST FEED THRU.

4. REMOVE TRACE ON SOLDER SIDE OF PCB THAT RUNS FROM PL102-10 TO R106.

5. REMOVE TRACE ON SOLDER SIDE OF PCB THAT RUNS FROM PL102-6 TO RV102.

6. REMOVE COPPER CLAD, GROUND PLANE, ON COMPONENT SIDE OF PCB AS SHOWN. DO NOT REMOVE PAD AT PL103-4, BUT ENSURE GROUND PLANE TRACES TO PL103-4 ARE REMOVED ALL THE WAY TO PL103-4.

7. REMOVE COPPER CLAD, GROUND PLANE, ON SOLDER SIDE OF PCB AS SHOWN.

8. INSTALL 22 AWG BUSS WIRE, ITEM 4, WITH TFE SLEEVING, ITEM 3, FROM PL102-6 TO RV102, AS SHOWN.

9. INSTALL 22 AWG BUSS WIRE, ITEM 4, WITH TFE SLEEVING, ITEM 3, FROM PL103-2, TO IC107-4 AS SHOWN.

10. INSTALL 22 AWG BUSS WIRE, ITEM 4, WITH TFE SLEEVING, ITEM 3, FROM PL103-4, TO GROUND PLANE AS SHOWN.

11. CUT ONE LENGTH OF 3/16 SHRINK TUBING, ITEM 6, TO .9 INCHES. CUT TWO LENGTHS OF 22 AWG TFE SLEEVING, ITEM 3, TO .45 INCHES. CUT ONE LEAD OF R106 TO .6 INCHES FROM R106 BODY. MODIFY ONE SPACER, ITEM 5, AS SHOWN IN SECTION D-D.

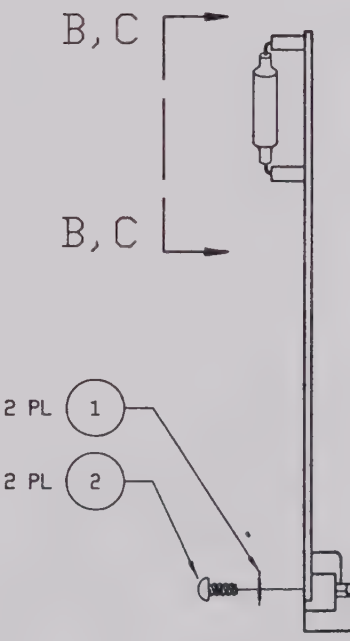
12. ASSEMBLE TFE SLEEVING, ITEM 3, AND MODIFIED SPACER, ITEM 5, ONTO CUT LEAD OF R106.

13. INSERT ASSEMBLED LEAD OF R106 INTO PL102-10 PAD WITH PL102 INSTALLED UNTIL TFE SLEEVING, ITEM 3 IS .1 INCHES FROM SOLDER SIDE OF PCB. SOLDER PL102 AND R106 LEAD TO PCB. SLIDE MODIFIED SPACER DOWN FLUSH TO PCB AND BEND R106 LEAD AT A 90° ANGLE TIGHTLY AGAINST SPACER.

14. SLIDE 3/16 SHRINK SLEEVING, ITEM 6, OVER R106 BODY. DO NOT SHRINK YET.

15. ASSEMBLE TFE SLEEVING
SPACER ,ITEM 5, ONTO C
LEAD AT A 90° ANGLE OV
ENSURING SPACER IS ON
INSTALL LEAD IN DESIGN
SPACER FLUSH TO PCB AN
AGAINST SPACER. SOLDER
OF PCB AND TRIM LEAD.

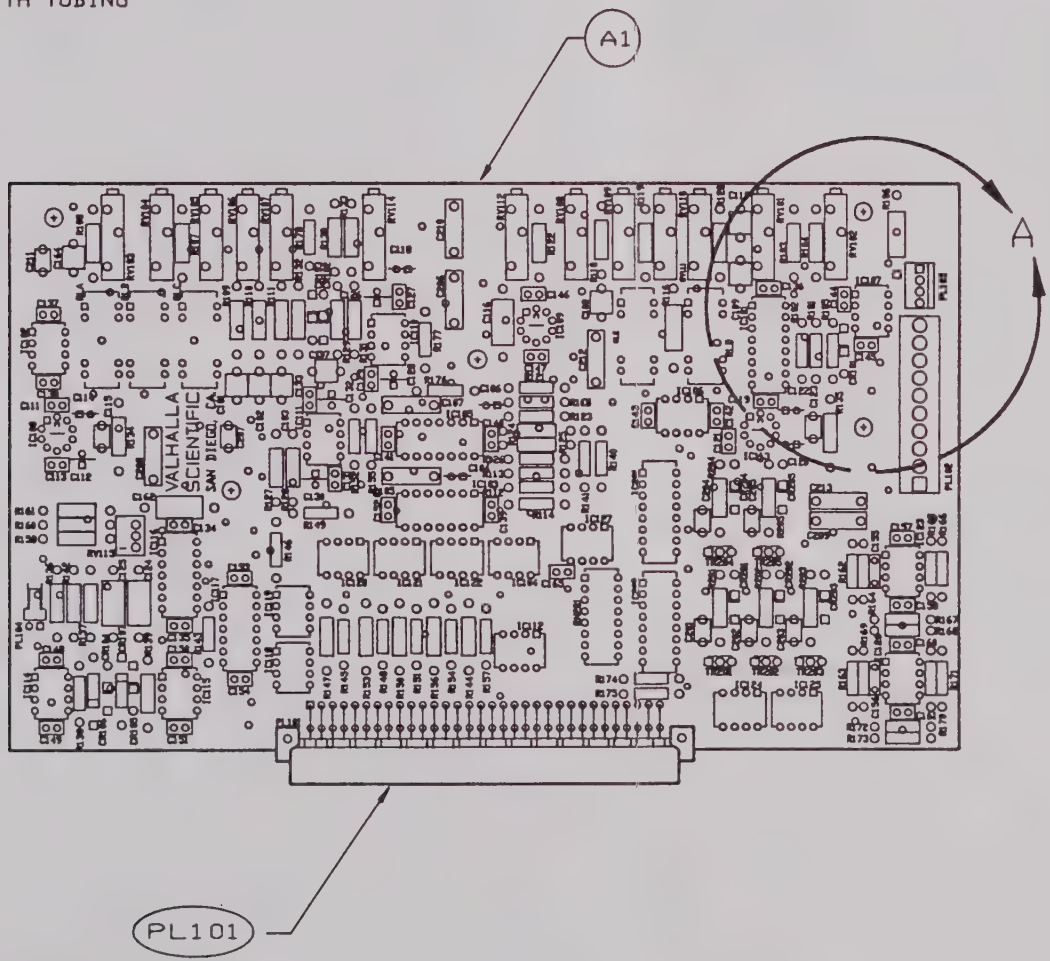
16. SHRINK 3/16 TUBING , I
CENTERED BETWEEN SPACE



REVISIONS				
ECO#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

ITEM 3, AND UNMODIFIED
HER R106 LEAD. BEND
R DESIGNATED HOLE PAD
CB SIDE OF BEND.
TED HOLE PAD WITH
R106 LEAD TIGHTLY
ON COMPONENT SIDE

M 6, WITH TUBING
S.



CES:
= ± 30'
= ± .02
X = ± .005

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FINISH:

MATERIAL:

SCALE: 1 : 1

STOCK NO. 30-00146

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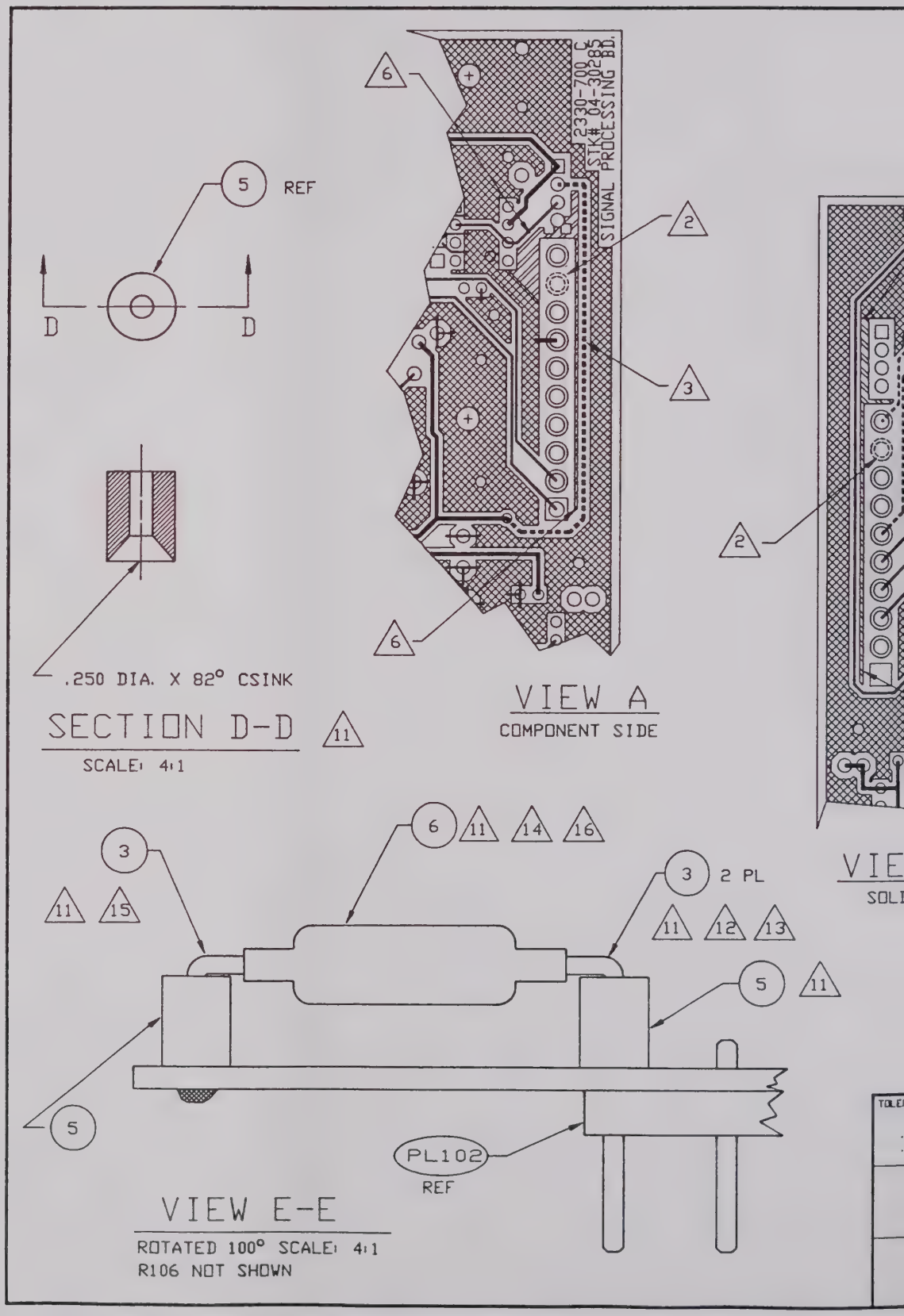
9955 MESA RIM RD. SAN DIEGO, CA 92121

TITLE
ASSEMBLY-
SIGNAL PROCESSING BD.

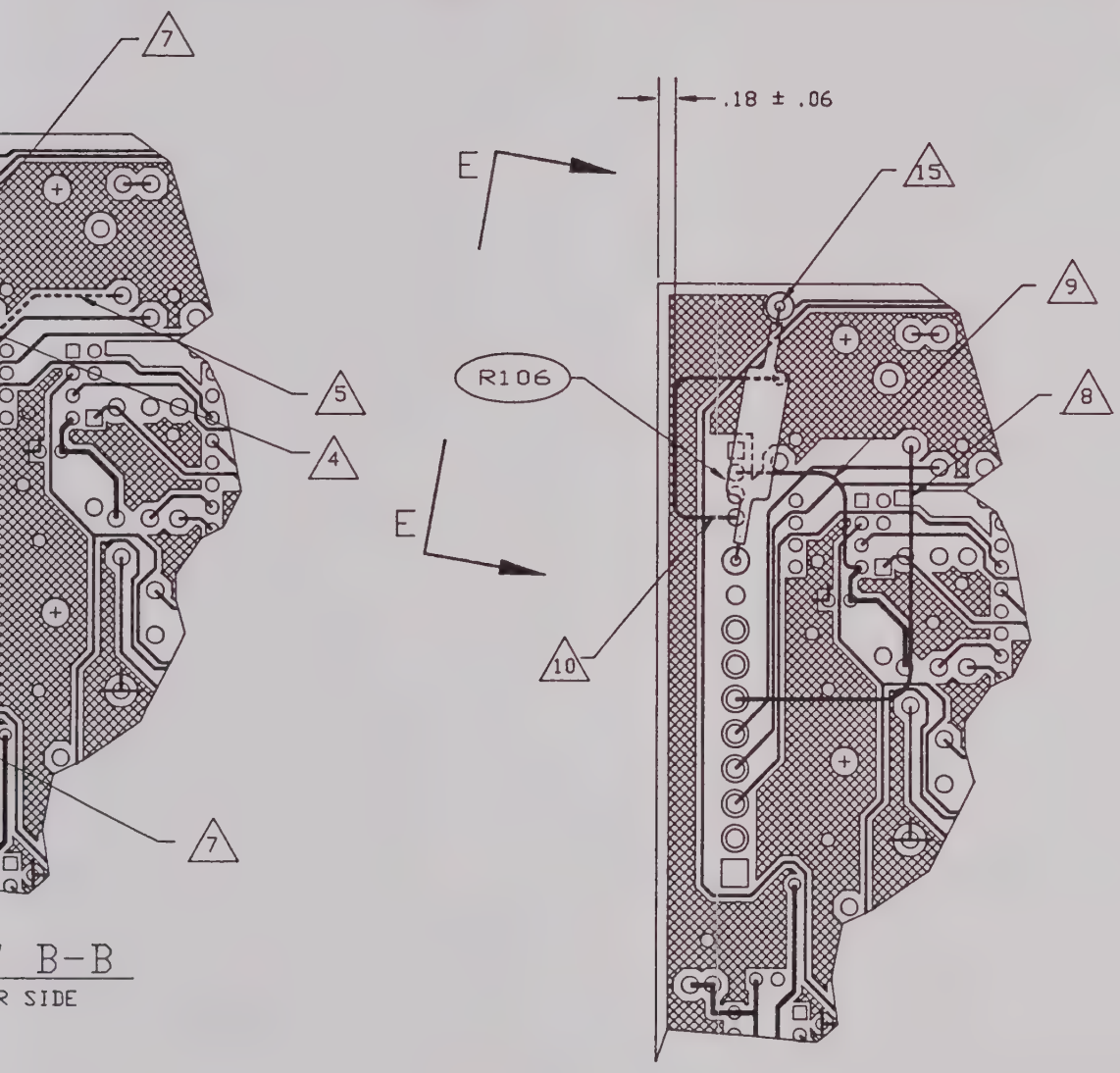
SHEET 1 OF 2

DRAWING NO. 2330-600

REV: G


5 REF
D
D
.250 DIA. X 82° CSINK
SECTION D-D
11
SCALE: 4:1
6
2
3
6
STK# 2330-700 C
04-302 B5
SIGNAL PROCESSING BD.
VIEW A
COMPONENT SIDE
2
VIE
SOLI
3
11
15
6
11
14
16
3
2 PL
11
12
13
5
11
5
PL102
REF
VIEW E-E
ROTATED 100° SCALE: 4:1
R106 NOT SHOWN

REVISIONS				
ECO#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED
		SEE SH 1		



B-B
R SIDE

VIEW C-C
SOLDER SIDE

CES:
= ± 30'
= ± .02
= ± .005

BURR AND
EAK ALL
RP EDGES
CORNERS

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NISH OF

FINISH:

MATERIAL:

SCALE: NOTED

STOCK NO. 30-00146

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TITLE
ASSEMBLY-
SIGNAL PROCESSING BD.

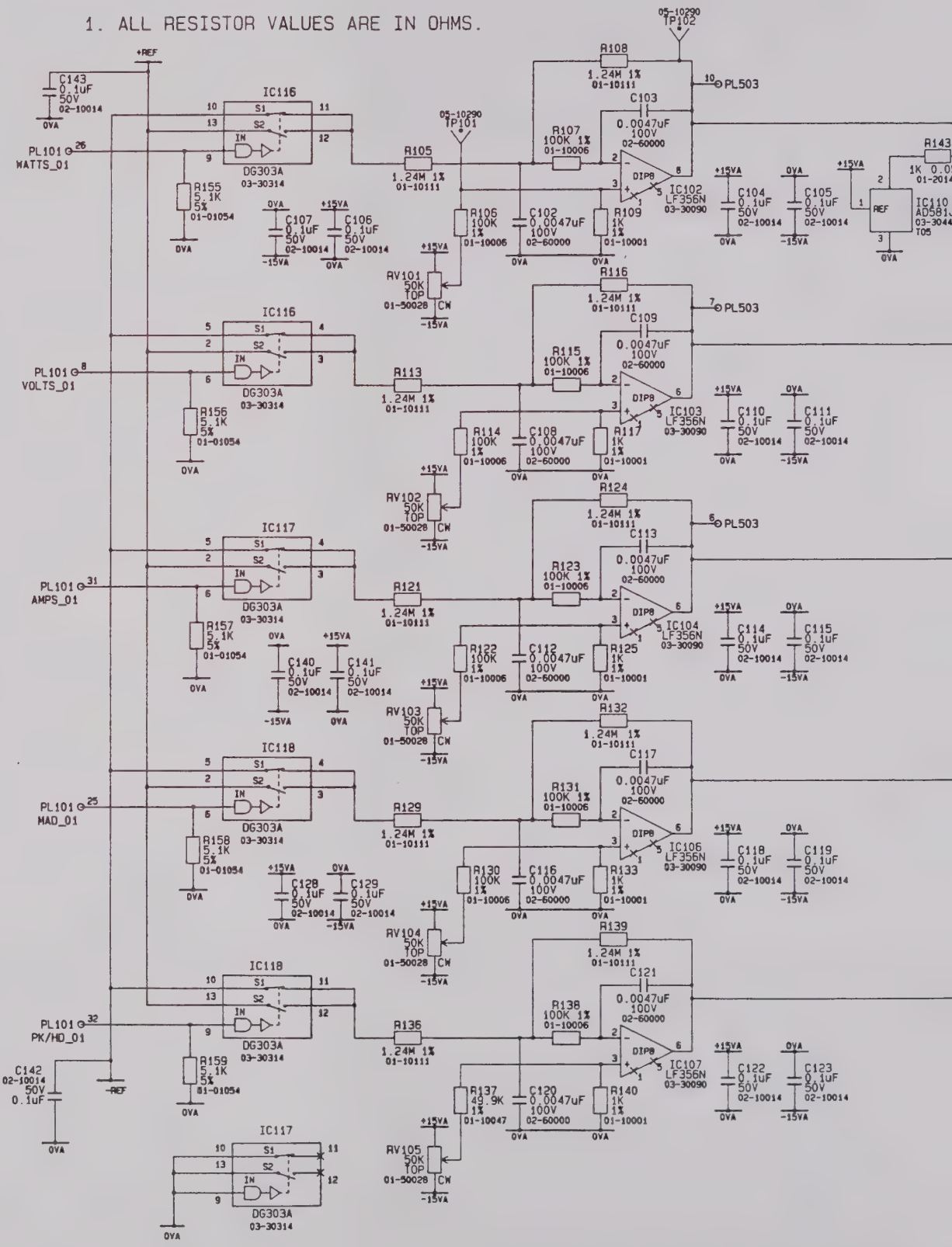
SHEET 2 OF 2

DRAWING NO. 2330-600

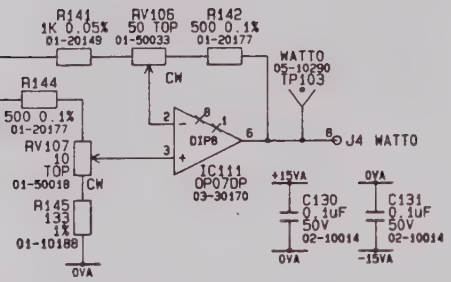
REV: G

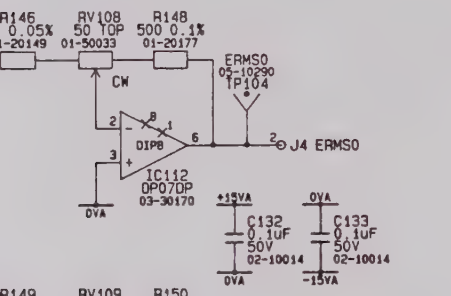
NOTES: Unless Otherwise Specified

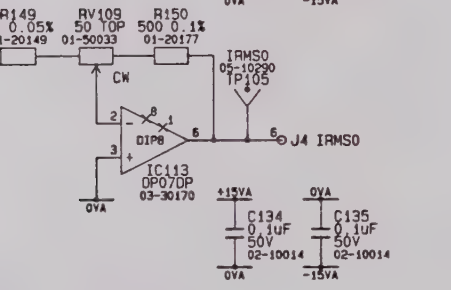
1. ALL RESISTOR VALUES ARE IN OHMS.

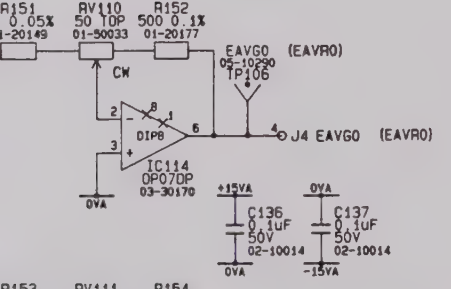


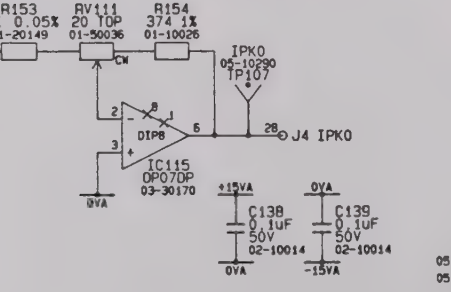
REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

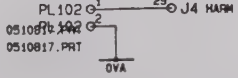


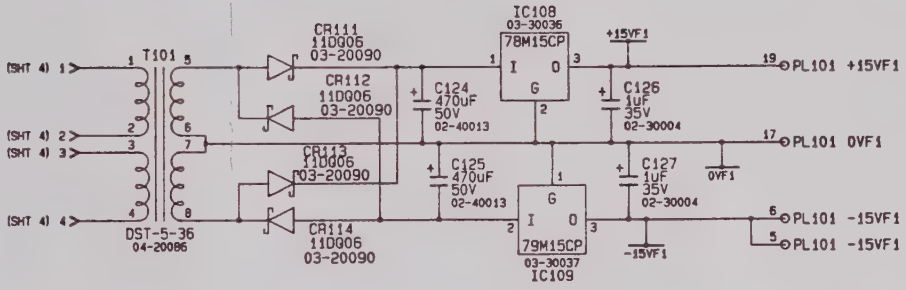












TP101		TP107
T101		T102
RV101		RV111
R101		R159
RL101		RL103
PL101		PL102
IC101		IC118
CR101		CR114
C101		C143
FIRST USED	NOT USED	LAST USED

DEVICE	+15VA	-15VA	0VA	PACKAGE
IC118	14	8	7	DIP14
IC117	14	8	7	DIP14
IC116	14	8	7	DIP14
IC115	7	4		DIP8
IC114	7	4		DIP8
IC113	7	4		DIP8
IC112	7	4		DIP8
IC111	7	4		DIP8
IC110	SHOWN		SHOWN	TO5
IC109				TO220
IC108				TO220
IC107	7	4		DIP8
IC106	7	4		DIP8
IC104	7	4		DIP8
IC103	7	4		DIP8
IC102	7	4		DIP8
IC101				

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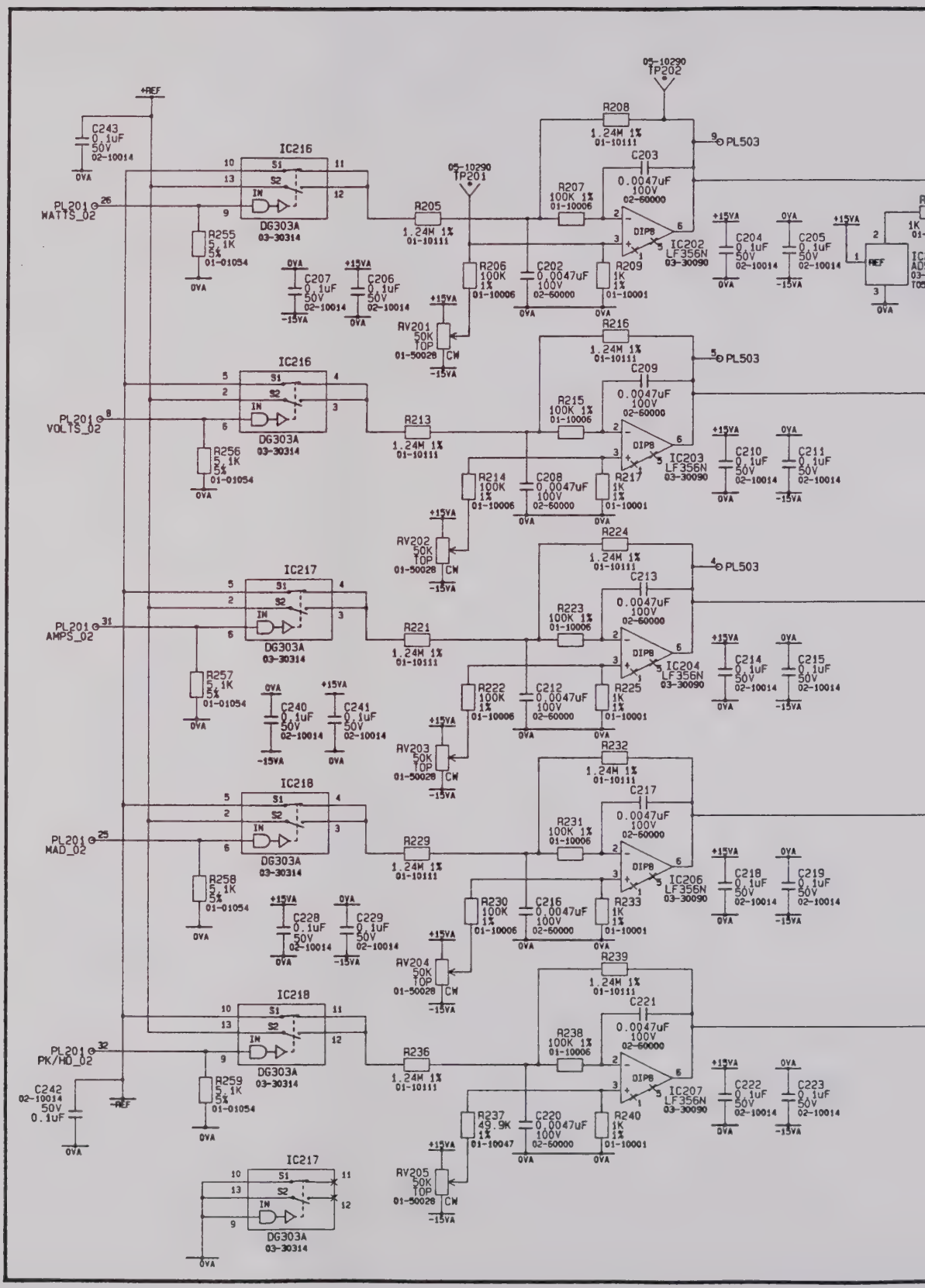
TITLE: SCHEMATIC- MOTHER BOARD

SHEET 1 OF 4 | DRAWING NO. 2330-071 | REV: F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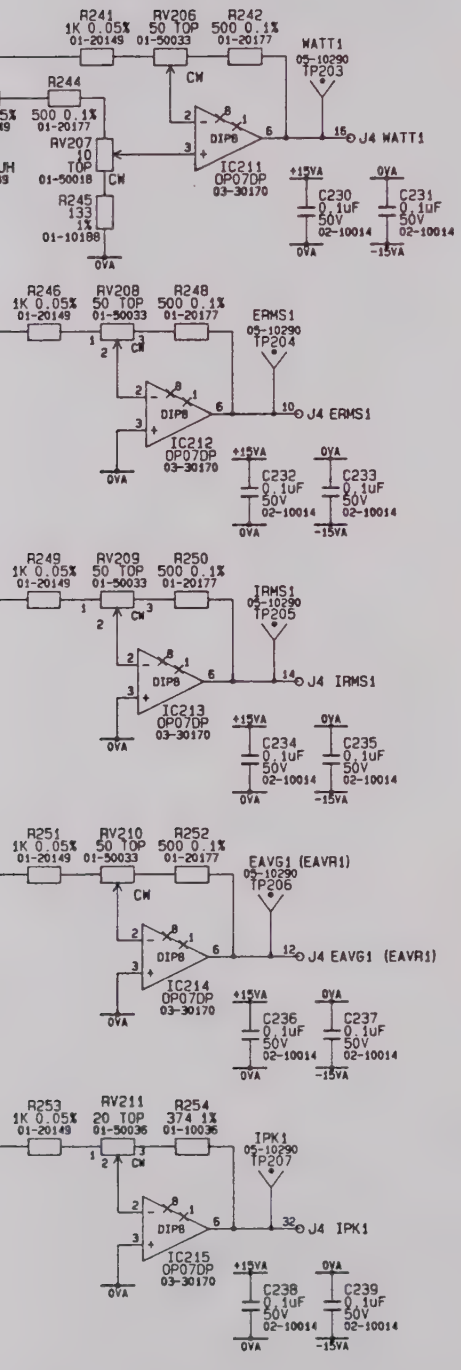
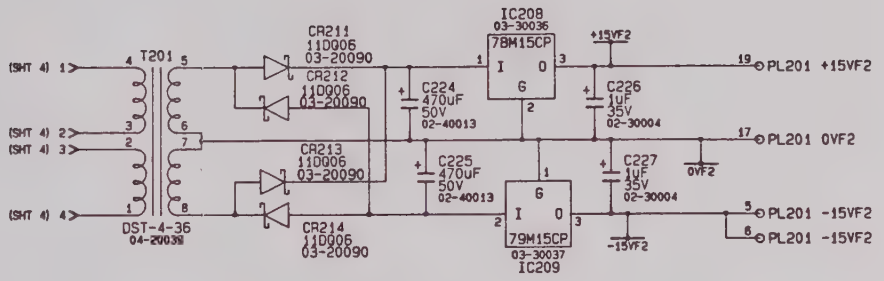
C243 0.1uF 50V 02-10014
0VA
IC216
DG303A 03-30314
PL201 WATTS_02
R255 5.1K 5% 01-01054
R205 1.24M 1% 01-10111
05-10290 TP201
05-10290 TP202
R208 1.24M 1% 01-10111
PL503
C203 0.0047uF 100V 02-60000
R207 100K 1% 01-10006
IC202 LF356N 03-30090
R206 100K 1% 01-10006
C202 0.0047uF 100V 02-60000
R209 1K 1% 01-10001
C207 0.1uF 50V 02-10014
C206 0.1uF 50V 02-10014
+15VA
-15VA
RV201 50K TOP 01-50028 CW
C204 0.1uF 50V 02-10014
C205 0.1uF 50V 02-10014
R216 1.24M 1% 01-10111
C209 0.0047uF 100V 02-60000
R215 100K 1% 01-10006
IC203 LF356N 03-30090
R213 1.24M 1% 01-10111
R214 100K 1% 01-10006
C208 0.0047uF 100V 02-60000
R217 1K 1% 01-10001
C210 0.1uF 50V 02-10014
C211 0.1uF 50V 02-10014
PL201 VOLTS_02
R256 5.1K 5% 01-01054
RV202 50K TOP 01-50028 CW
R224 1.24M 1% 01-10111
C213 0.0047uF 100V 02-60000
R223 100K 1% 01-10006
IC204 LF356N 03-30090
R221 1.24M 1% 01-10111
R222 100K 1% 01-10006
C212 0.0047uF 100V 02-60000
R225 1K 1% 01-10001
C214 0.1uF 50V 02-10014
C215 0.1uF 50V 02-10014
PL201 AMPS_02
R257 5.1K 5% 01-01054
C240 0.1uF 50V 02-10014
C241 0.1uF 50V 02-10014
RV203 50K TOP 01-50028 CW
R232 1.24M 1% 01-10111
C217 0.0047uF 100V 02-60000
R231 100K 1% 01-10006
IC206 LF356N 03-30090
R229 1.24M 1% 01-10111
R230 100K 1% 01-10006
C216 0.0047uF 100V 02-60000
R233 1K 1% 01-10001
C218 0.1uF 50V 02-10014
C219 0.1uF 50V 02-10014
PL201 MAD_02
R258 5.1K 5% 01-01054
C228 0.1uF 50V 02-10014
C229 0.1uF 50V 02-10014
RV204 50K TOP 01-50028 CW
R239 1.24M 1% 01-10111
C221 0.0047uF 100V 02-60000
R238 100K 1% 01-10006
IC207 LF356N 03-30090
R236 1.24M 1% 01-10111
R237 49.9K 1% 01-10047
C220 0.0047uF 100V 02-60000
R240 1K 1% 01-10001
C222 0.1uF 50V 02-10014
C223 0.1uF 50V 02-10014
PL201 PK/HD_02
R259 5.1K 5% 01-01054
C242 02-10014 50V 0.1uF
RV205 50K TOP 01-50028 CW
IC217
DG303A 03-30314

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

SEE SHEET 1 FOR ALL REVISIONS





NOTES: SINGLE CHANNEL UNITS HAVE THE FOLLOWING POINTS CONNECTED TO 0VA:

J4-16	WATT1
J4-10	ERMS1
J4-14	IRMS1
J4-12	EAVG1
J4-32	IPK1

TP201		TP207
T201		T201
RV201		RV211
R201		R259
RL201		RL203
PL201		PL202
IC201		IC218
CR201		CR214
C201		C243
FIRST USED	NOT USED	LAST USED

IC218	14	8	7	DIP8
IC217	14	8	7	DIP8
IC216	14	8	7	DIP8
IC215	7	4	——	DIP8
IC214	7	4	——	DIP8
IC213	7	4	——	DIP8
IC212	7	4	——	DIP8
IC211	7	4	——	DIP8
IC210	SHOWN	——	SHOWN	TO5
IC209	——	——	——	TO220
IC208	——	——	——	TO220
IC207	7	4	——	DIP8
IC206	7	4	——	DIP8
IC204	7	4	——	DIP8
IC203	7	4	——	DIP8
IC202	7	4	——	DIP8
DEVICE	+15VA	-15VA	0VA	PACKAGE

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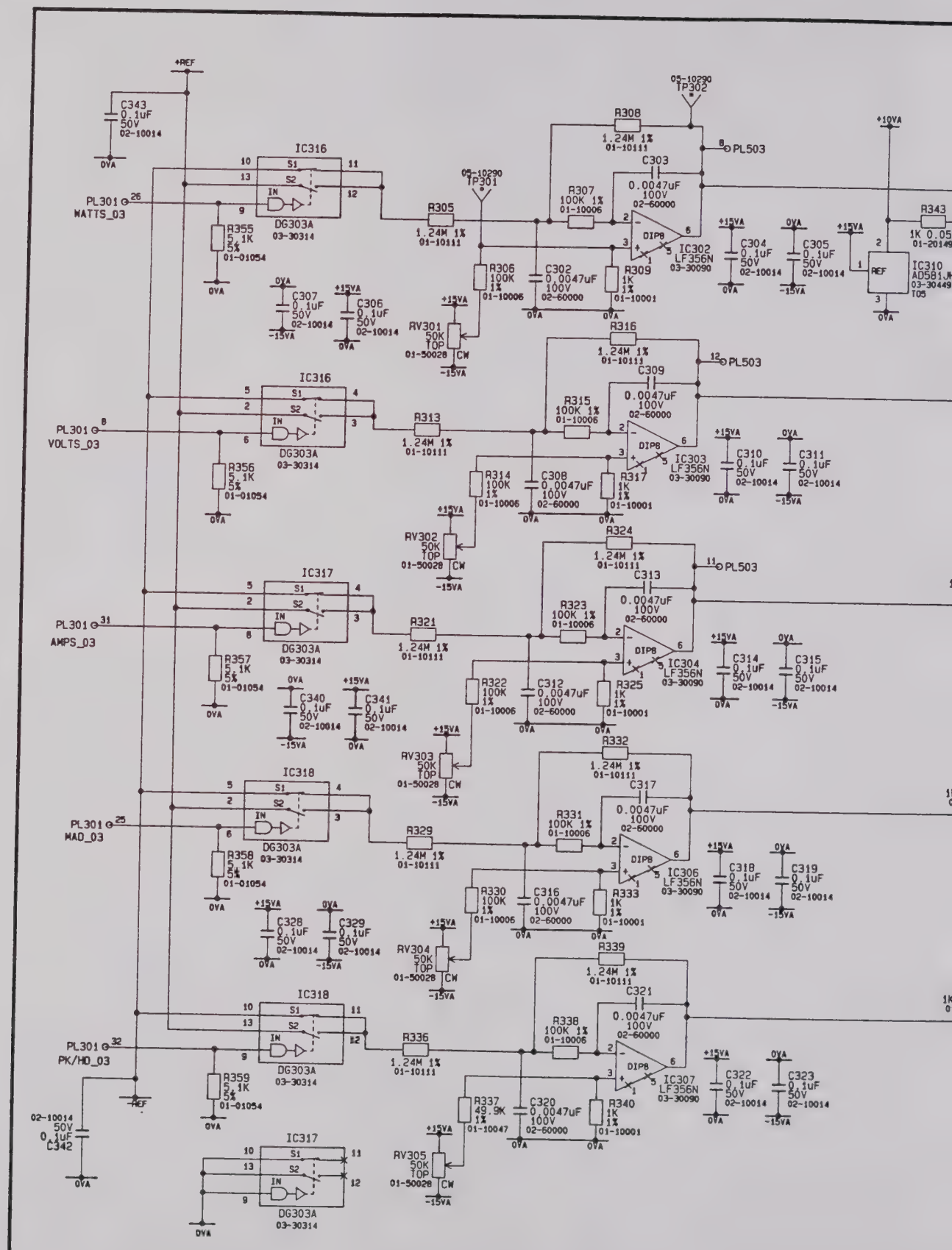
TITLE: SCHEMATIC- MOTHER BOARD

SHEET 2 OF 4 | DRAWING NO. 2330-071 | REV: F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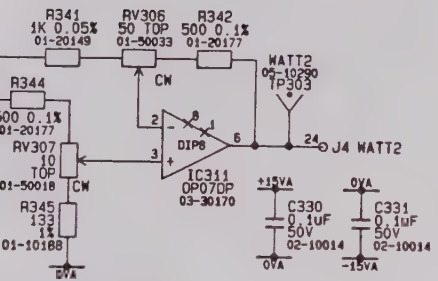
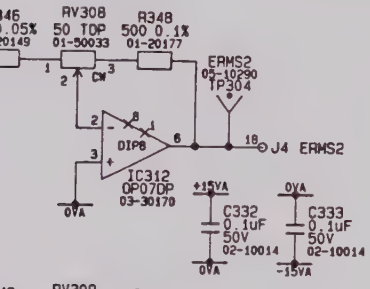
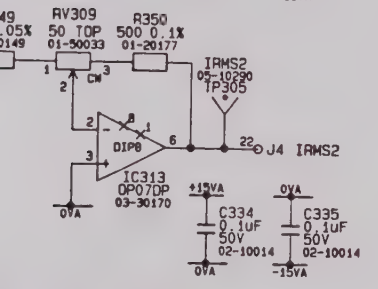
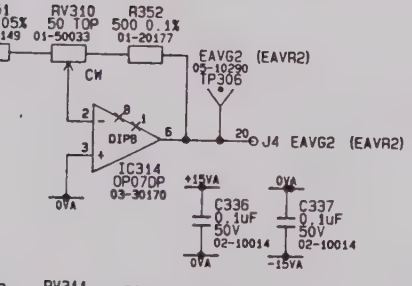
0VA
IC316
PL301 26 WATTS_03
DG303A 03-30314
R355 5.1K 5% 01-01054
R305 1.24M 1% 01-10111
05-10290 TP301
R307 100K 1% 01-10006
R308 1.24M 1% 01-10111
05-10290 TP302
8 PL503
C303 0.0047uF 100V 02-60000
IC302 LF356N 03-30090
DIP8
+15VA
-15VA
C304 0.1uF 50V 02-10014
C305 0.1uF 50V 02-10014
+10VA
R343 1K 0.05
01-20149
IC310 AD581JH 03-30449 TO5
REF
R306 100K 1% 01-10006
C302 0.0047uF 100V 02-60000
R309 1K 1% 01-10001
C307 0.1uF 50V 02-10014
C306 0.1uF 50V 02-10014
RV301 50K TOP CW 01-50028
R316 1.24M 1% 01-10111
12 PL503
C309 0.0047uF 100V 02-60000
IC316
PL301 8 VOLTS_03
DG303A 03-30314
R356 5.1K 5% 01-01054
R313 1.24M 1% 01-10111
R315 100K 1% 01-10006
IC303 LF356N 03-30090
C310 0.1uF 50V 02-10014
C311 0.1uF 50V 02-10014
R314 100K 1% 01-10006
C308 0.0047uF 100V 02-60000
R317 1K 1% 01-10001
RV302 50K TOP CW 01-50028
R324 1.24M 1% 01-10111
11 PL503
C313 0.0047uF 100V 02-60000
IC317
PL301 31 AMPS_03
DG303A 03-30314
R357 5.1K 5% 01-01054
R321 1.24M 1% 01-10111
R323 100K 1% 01-10006
IC304 LF356N 03-30090
C314 0.1uF 50V 02-10014
C315 0.1uF 50V 02-10014
R322 100K 1% 01-10006
C312 0.0047uF 100V 02-60000
R325 1K 1% 01-10001
C340 0.1uF 50V 02-10014
C341 0.1uF 50V 02-10014
RV303 50K TOP CW 01-50028
R332 1.24M 1% 01-10111
IC318
PL301 25 MAD_03
DG303A 03-30314
R358 5.1K 5% 01-01054
R329 1.24M 1% 01-10111
C317 0.0047uF 100V 02-60000
R331 100K 1% 01-10006
IC306 LF356N 03-30090
C318 0.1uF 50V 02-10014
C319 0.1uF 50V 02-10014
R330 100K 1% 01-10006
C316 0.0047uF 100V 02-60000
R333 1K 1% 01-10001
C328 0.1uF 50V 02-10014
C329 0.1uF 50V 02-10014
RV304 50K TOP CW 01-50028
R339 1.24M 1% 01-10111
IC318
PL301 32 PK/HD_03
DG303A 03-30314
R359 5.1K 5% 01-01054
R336 1.24M 1% 01-10111
C321 0.0047uF 100V 02-60000
R338 100K 1% 01-10006
IC307 LF356N 03-30090
C322 0.1uF 50V 02-10014
C323 0.1uF 50V 02-10014
02-10014 50V 0.1uF C342
R337 49.9K 1% 01-10047
C320 0.0047uF 100V 02-60000
R340 1K 1% 01-10001
RV305 50K TOP CW 01-50028
IC317
DG303A 03-30314

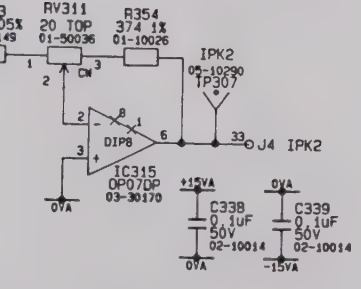
REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED
SEE SHEET 1 FOR ALL REVISIONS				

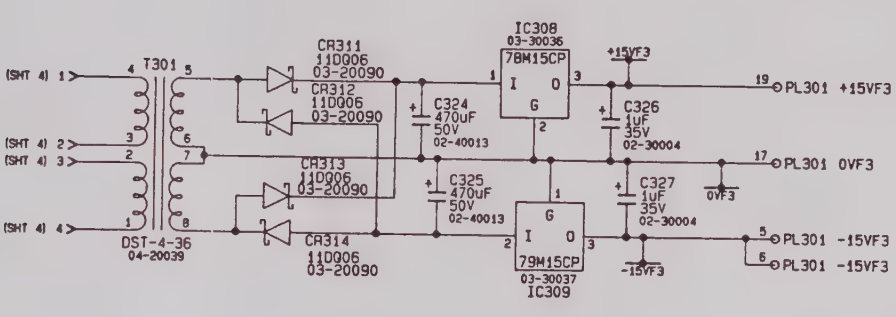












NOTES: SINGLE CHANNEL UNITS HAVE THE FOLLOWING POINTS CONNECTED TO 0VA:

J4-24	WATT2
J4-18	ERMS2
J4-22	IRMS2
J4-20	EVAG2
J4-33	IPK2

TP301	— — — — —	TP307
T301	— — — — —	T301
RV301	— — — — —	RV311
R301	— — — — —	R359
RL301	— — — — —	RL303
PL301	— — — — —	PL302
IC301	— — — — —	IC318
CR301	— — — — —	CR314
C301	— — — — —	C343
FIRST USED	NOT USED	LAST USED

IC318	14	8	7	DIP14
IC317	14	8	7	DIP14
IC316	14	8	7	DIP14
IC315	7	4	———	DIP8
IC314	7	4	———	DIP8
IC313	7	4	———	DIP8
IC312	7	4	———	DIP8
IC311	7	4	———	DIP8
IC310	SHOWN	———	SHOWN	T05
IC309	———	———	———	T0220
IC308	———	———	———	T0220
IC307	7	4	———	DIP8
IC306	7	4	———	DIP8
IC304	7	4	———	DIP8
IC303	7	4	———	DIP8
IC302	7	4	———	DIP8
DEVICE	+15VA	-15VA	0VA	PACKAGE

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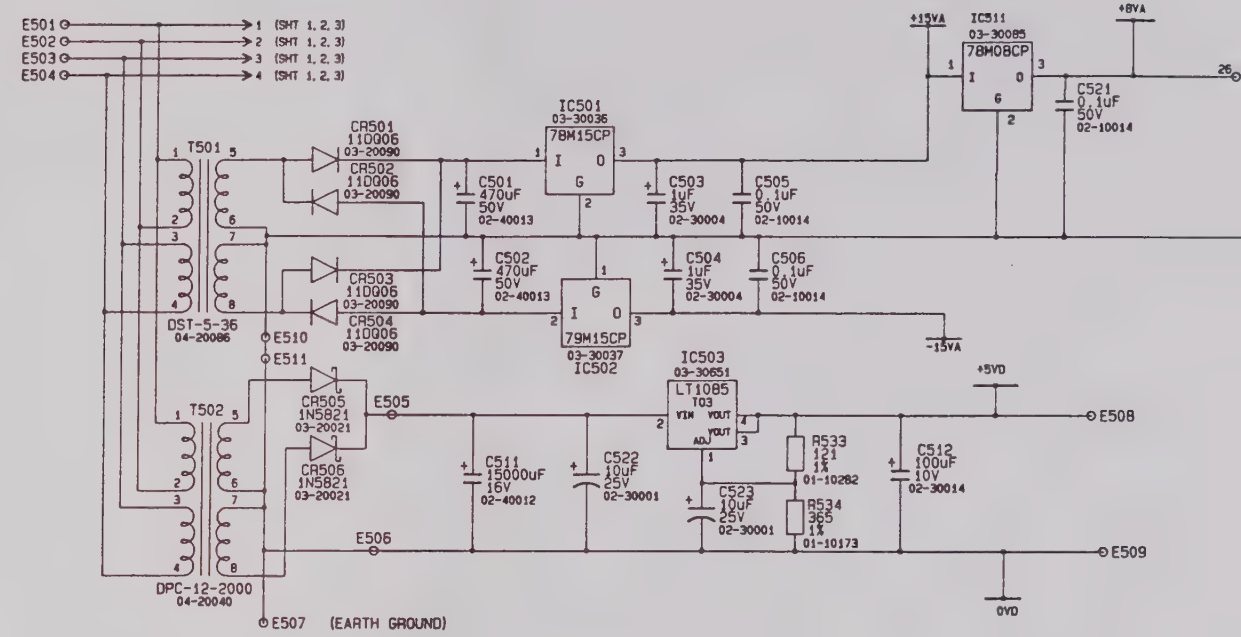
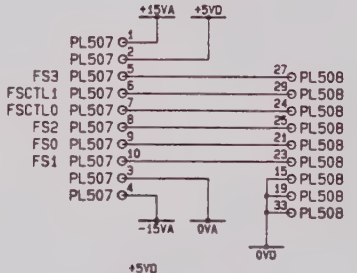
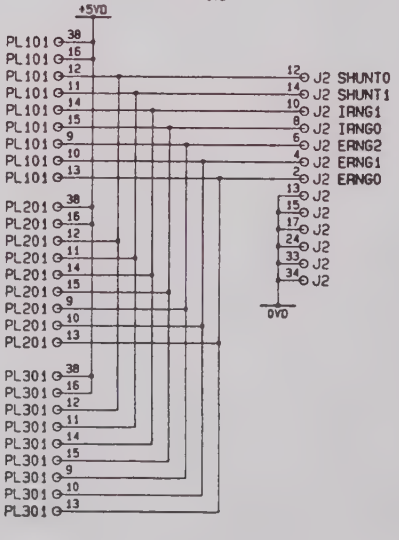
VALHALLA SCIENTIFIC
9955 MESA RIM RD. SAN DIEGO, CA 92121

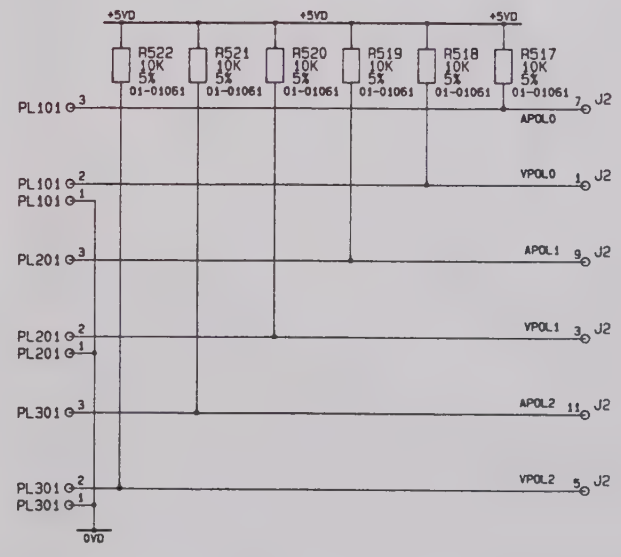
TITLE: SCHEMATIC- MOTHER BOARD

SHEET 3 OF 4 | DRAWING NO. 2330-071 | REV: F

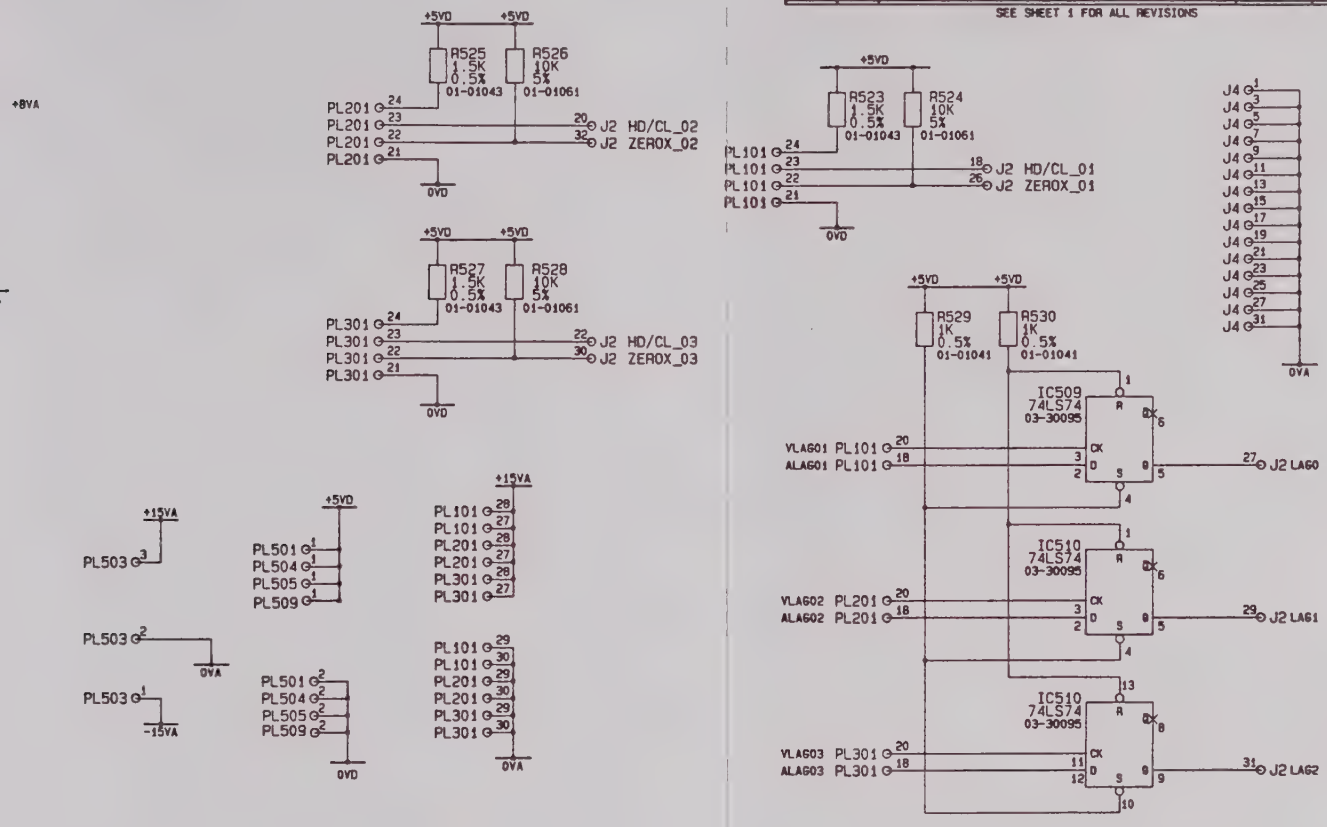

E501
E502
E503
E504
(SHT 1, 2, 3)
T501
DST-5-36
04-20086
CR501
CR502
CR503
CR504
11DQ06
03-20090
IC501
03-30036
78M15CP
IC502
79M15CP
03-30037
C501
470uF
50V
02-40013
C502
C503
1uF
35V
02-30004
C504
C505
0.1uF
50V
02-10014
C506
E510
E511
T502
DPC-12-2000
04-20040
CR505
CR506
1N5821
03-20021
E505
E506
E507
(EARTH GROUND)
IC503
03-30651
LT1085
TO3
C511
15000uF
16V
02-40012
C522
10uF
25V
02-30001
C523
R533
121
1%
01-10282
R534
365
01-10173
C512
100uF
10V
02-30014
E508
E509
+15VA
-15VA
+5VD
0VD
IC511
03-30085
78M08CP
C521
26

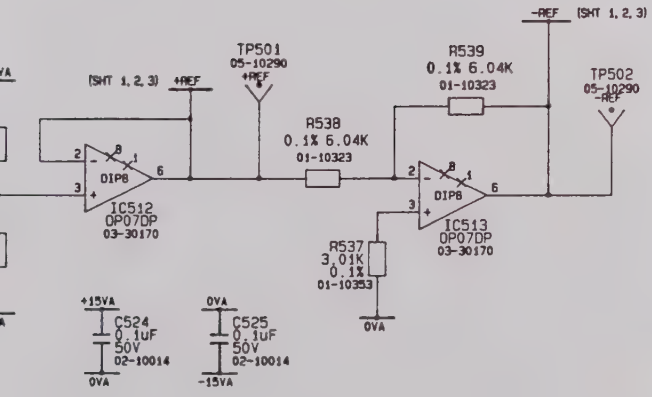

+15VA
+5VD
PL507
FS3
FSCTL1
FSCTL0
FS2
FS0
FS1
PL508
-15VA
0VA
0VD


+5VD
PL101
PL201
PL301
J2 SHUNT0
J2 SHUNT1
J2 IRNG1
J2 IRNG0
J2 ERNG2
J2 ERNG1
J2 ERNG0
J2
0VD


+5VD
R522
R521
R520
R519
R518
R517
10K
5%
01-01061
PL101
PL201
PL301
APOL0
VPOL0
APOL1
VPOL1
APOL2
VPOL2
J2
0VD

REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED
SEE SHEET 1 FOR ALL REVISIONS				





TP501	— — — — —	TP502
T501	— — — — —	T502
R501	— — — — —	R539
PL501	— — — — —	PL510
J2	J3	J8
IC501	— — — — —	IC513
E501	— — — — —	E510
CR501	— — — — —	CR508
C501	— — — — —	C525
FIRST USED	NOT USED	LAST USED

IC513	7	4	——	——	——	——
IC512	7	4	——	——	——	——
IC510	——	——	——	14	7	DIP14
IC509	——	——	——	14	7	DIP14
IC503	——	——	——	SHOWN	SHOWN	TO3
IC502	——	SHOWN	SHOWN	——	——	TO220
IC501	SHOWN	——	SHOWN	——	——	TO220
DEVICE	+15VA	-15VA	0VA	+5VD	0VD	PACKAGE

TES: SINGLE CHANNEL UNITS HAVE THE
FOLLOWING POINTS CONNECTED TO 0VD:

PL201-22	ZEROX_02
PL301-22	ZEROX_03
J2-29	LAG1
J2-31	LAG2

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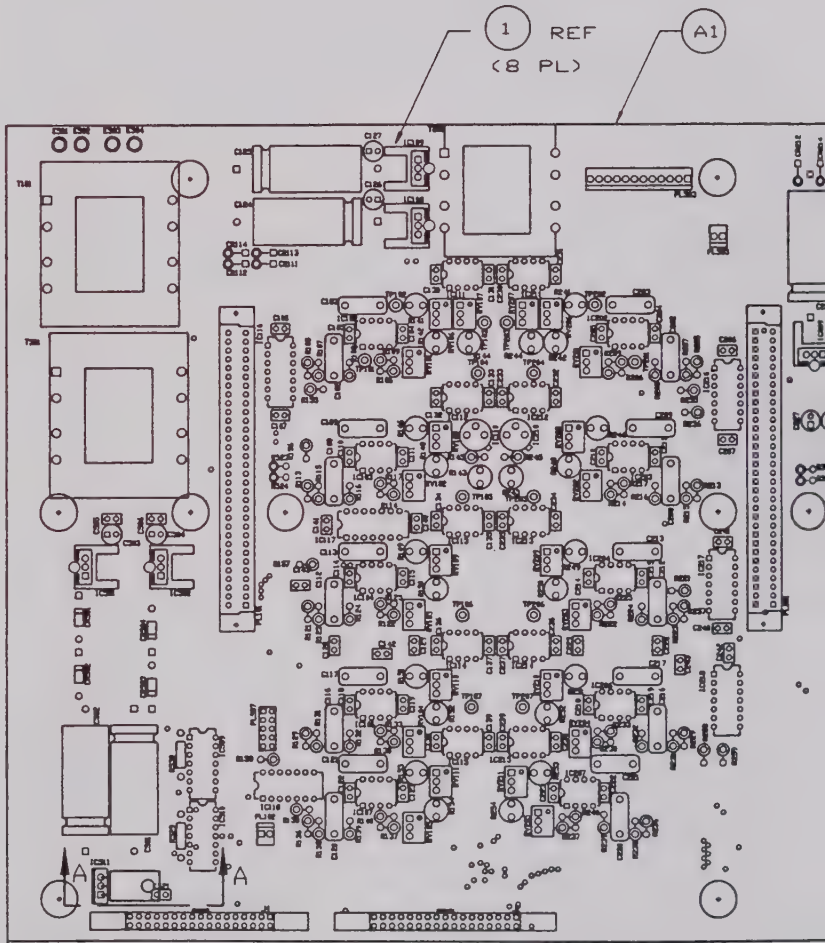
VALHALLA SCIENTIFIC
9955 MESA RIM RD. SAN DIEGO, CA 92121

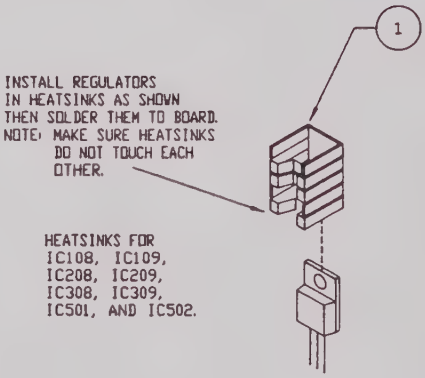
TITLE: SCHEMATIC- MOTHER BOARD

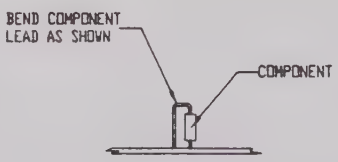
SHEET 4 OF 4 | DRAWING NO. 2330-071 | REV: F

NOTES: Unless Otherwise Specified

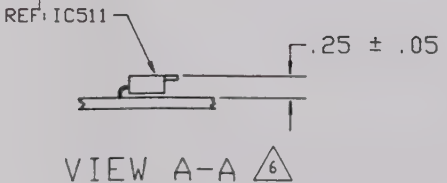
1. SEE SEPARATE PARTS LIST.
2. SOLDER HEATSINK TO P.C.B.
3. THESE WIRES ARE TO BE TWISTED APPROXIMATELY 1 TO 2 TWISTS PER INCH.
4. INSTALL CRIMP CONTACTS AS PER MANUFACTURERS RECOMMENDED PROCEDURE, USING MANUFACTURERS RECOMMENDED TOOLS.
5. MARK CONNECTOR WITH REFERENCE DESIGNATOR AS SHOWN USING A PERMANENT MARKER (COLOR: BLACK) FOR MARKING NYLON (PANDUIT PFX-0).
6. BEND IC511 OVER AS SHOWN. INSTALL WITHOUT HEATSINK.




1
INSTALL REGULATORS IN HEATSINKS AS SHOWN THEN SOLDER THEM TO BOARD.
NOTE: MAKE SURE HEATSINKS DO NOT TOUCH EACH OTHER.
HEATSINKS FOR IC108, IC109, IC208, IC209, IC308, IC309, IC501, AND IC502.



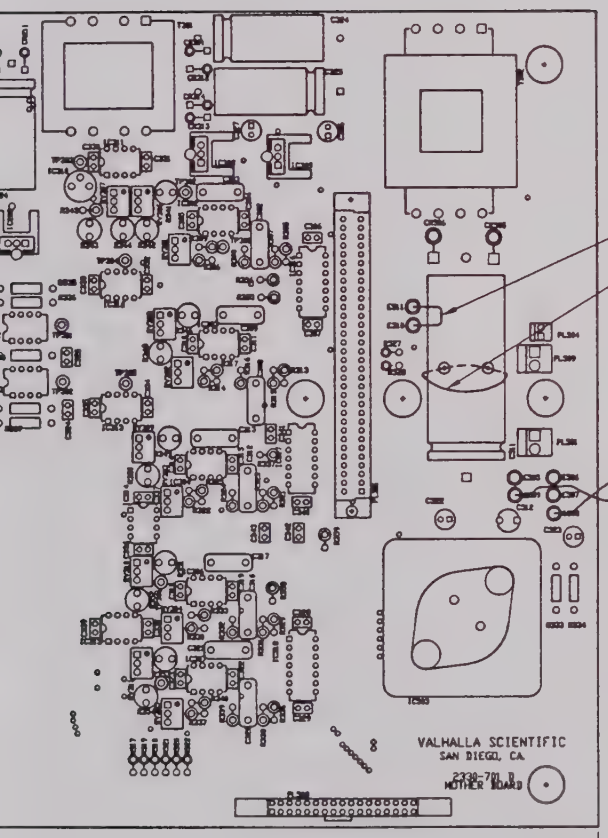
STAND UP COMPONENT DETAIL

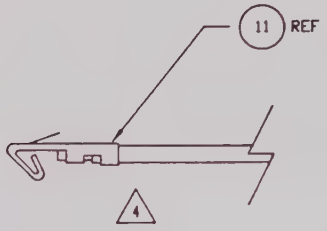


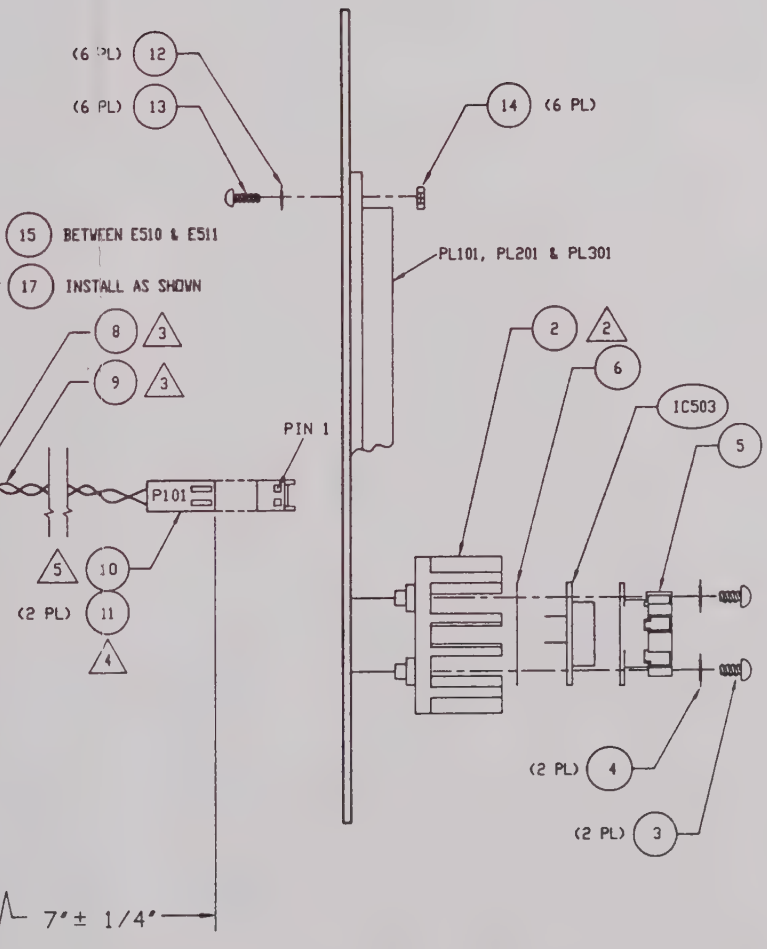
VIEW A-A 6

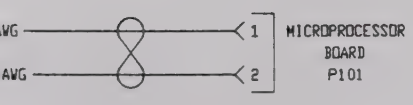
WIRING DI

REVISIONS				
ECO#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



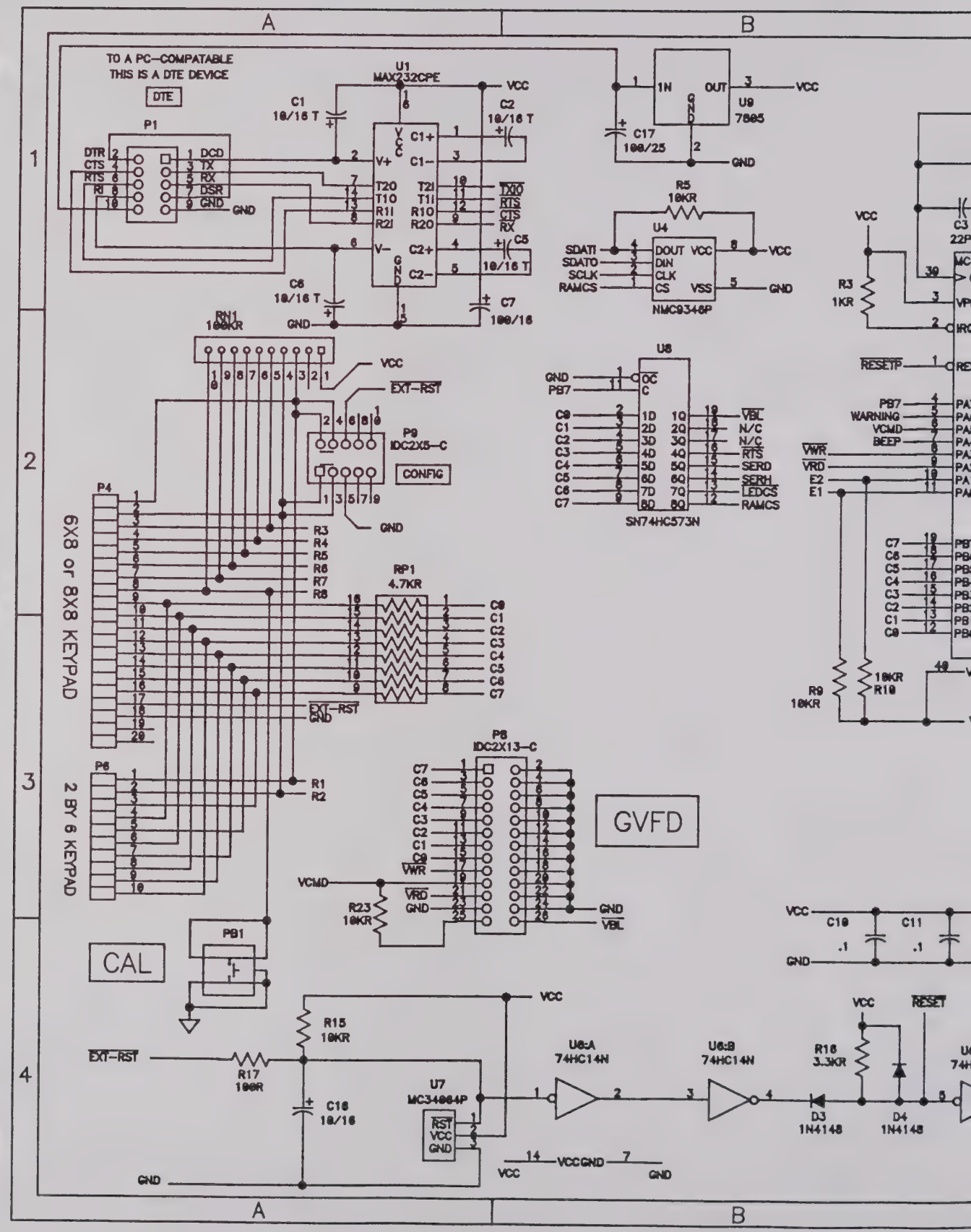


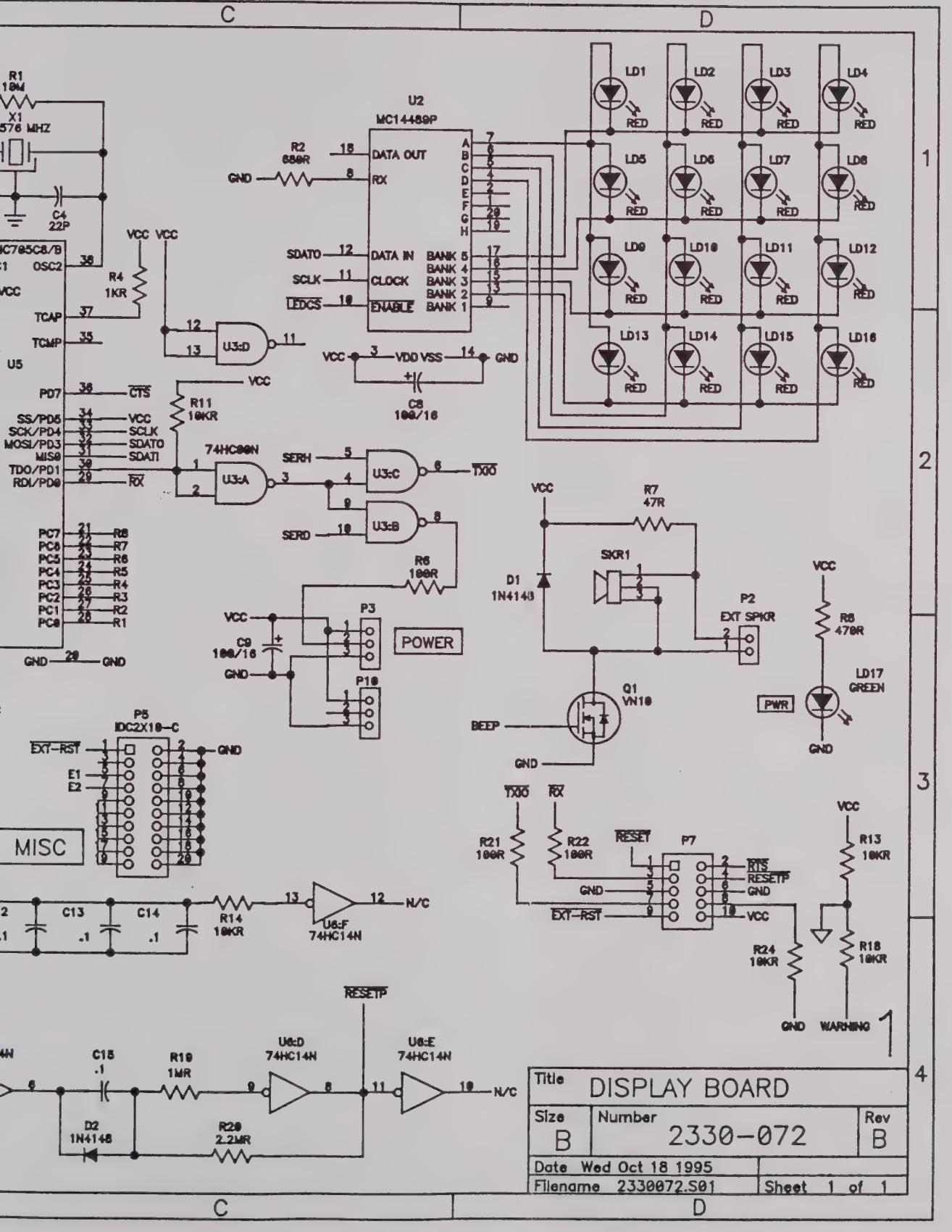




GRAM 3

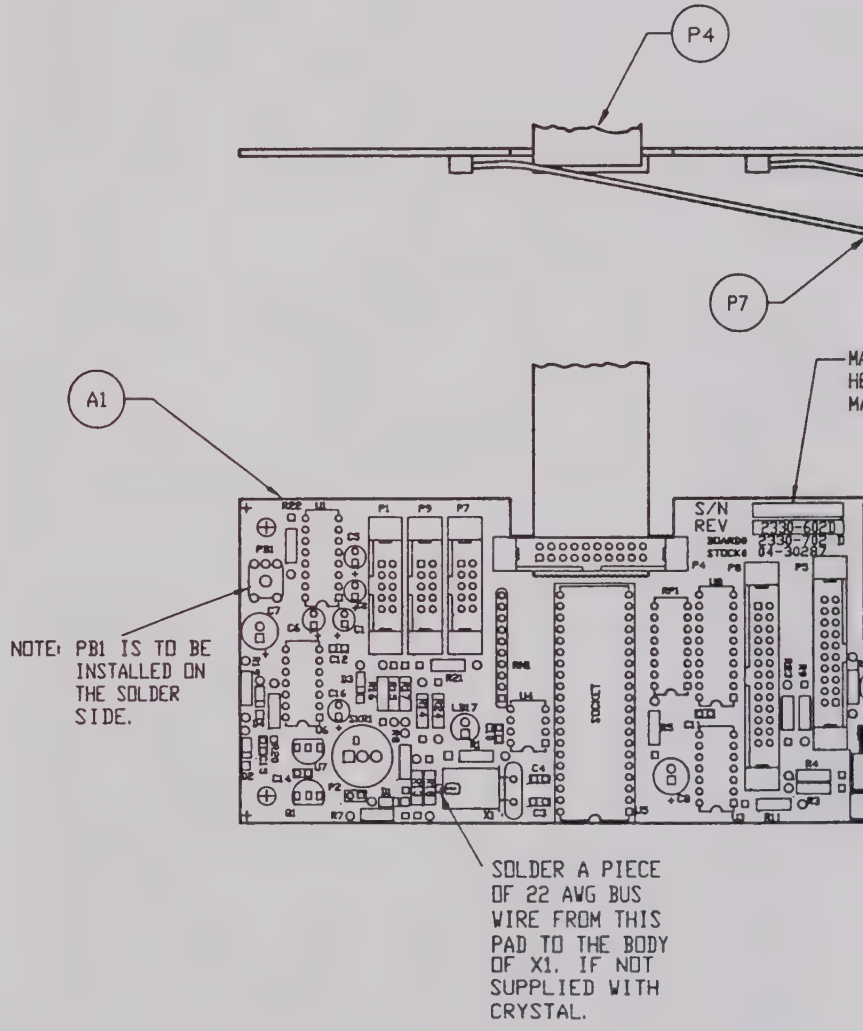
TOLERANCES: X = ± .39", .XX = ± .02, .XXX = ± .005	FINISH:	MATERIAL:		VALHALLA SCIENTIFIC 9955 MESA RIM RD. SAN DIEGO, CA 92121
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS			THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC, INC. AND IS LOANED SUBJECT TO AGREEMENT FOR RIGHTS EXPRESSLY GRANTED TO THE UNITED STATES GOVERNMENT. VALHALLA SCIENTIFIC, INC. HOLDS ALL PATENT, COPYRIGHT, PROPRIETARY DESIGN, MANUFACTURING, USE AND REPRODUCTION RIGHTS THEREIN.	TITLE: ASSEMBLY- MAIN MOTHER BOARD
MACHINED SURFACES ARE TO HAVE A FINISH OF 63	SCALE: 1 : 1	STOCK NO. 30-00147		SHEET 1 OF 1 — DRAWING NO. 2330-601 — REV. L


TO A PC-COMPATABLE
THIS IS A DTE DEVICE
DTE
P1
DTR
CTS
RTS
RI
DCD
TX
RX
DSR
GND
U1
MAX232CPE
C1
10/16 T
C2
10/16 T
C5
10/16 T
C6
10/16 T
C7
100/16
VCC
GND
U9
7805
IN
OUT
C17
100/25
R5
10KR
U4
NMC9346P
SDATI
SDATO
SCLK
RAMCS
DOUT
DIN
CLK
CS
VSS
RN1
100KR
EXT-RST
P9
IDC2X5-C
CONFIG
P4
6X8 or 8X8 KEYPAD
R3
R4
R5
R6
R7
R8
RP1
4.7KR
P6
2 BY 6 KEYPAD
R1
R2
U8
SN74HC573N
RESETP
WARNING
VCMD
BEEP
VWR
VRD
E2
E1
SERD
SERH
LEDCS
RAMCS
R9
10KR
R10
10KR
P8
IDC2X13-C
GVFD
R23
10KR
PB1
CAL
R15
10KR
R17
100R
C16
10/16
U7
MC34064P
U6:A
74HC14N
U6:B
74HC14N
R16
3.3KR
D3
1N4148
D4
1N4148
RESET
C19
.1
C11
.1

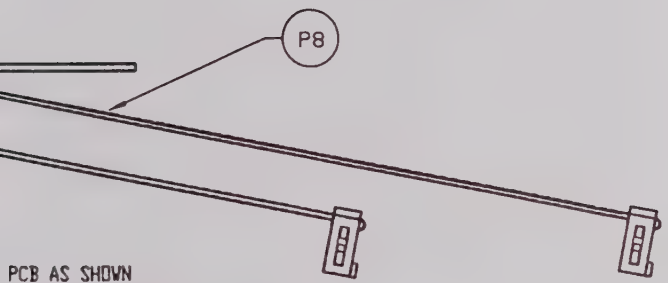

C
D
1
2
3
4
U2
MC14489P
DATA OUT
RX
DATA IN
CLOCK
ENABLE
BANK 5
BANK 4
BANK 3
BANK 2
BANK 1
SDATO
SCLK
LEDCS
R2
680R
GND
VCC
VDD
VSS
C8
100/16
LD1
LD2
LD3
LD4
LD5
LD6
LD7
LD8
LD9
LD10
LD11
LD12
LD13
LD14
LD15
LD16
RED
R1
10M
X1
4.576 MHZ
C4
22P
R4
1KR
U5
OSC2
TCAP
TCMP
PD7
CTS
SS/PD5
SCK/PD4
MOSI/PD3
MISO
TDO/PD1
RDI/PD0
RX
SCLK
SDATO
SDATI
PC7
PC6
PC5
PC4
PC3
PC2
PC1
PC0
R8
R7
R6
R5
R4
R3
R2
R1
U3:D
U3:A
U3:C
U3:B
74HC00N
SERH
SERD
TX00
R11
10KR
R6
100R
P3
POWER
C9
100/16
P10
R7
47R
SKR1
D1
1N4148
P2
EXT SPKR
Q1
VN10
BEEP
R8
470R
LD17
GREEN
PWR
P5
IDC2X10-C
EXT-RST
E1
E2
MISC
C13
C14
.1
R14
10KR
U6:F
74HC14N
N/C
R21
100R
R22
100R
RESET
P7
RTS
RESETP
R13
10KR
R24
10KR
R18
10KR
WARNING
C15
R19
1MR
U6:D
74HC14N
U6:E
74HC14N
D2
1N4148
R20
2.2MR
Title
DISPLAY BOARD
Size
B
Number
2330-072
Rev
B
Date Wed Oct 18 1995
Filename 2330072.S01
Sheet 1 of 1

NOTES: Unless Otherwise Specified

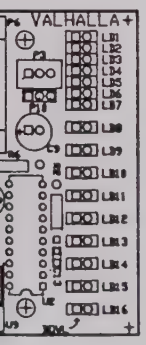
1. SEE SEPARATE PARTS LIST.

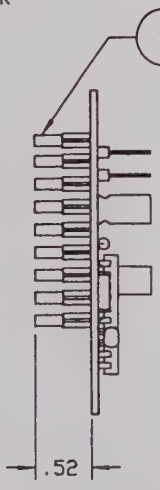

P4
P7
A1
S/N
REV
NOTE: PB1 IS TO BE INSTALLED ON THE SOLDER SIDE.
SOLDER A PIECE OF 22 AWG BUS WIRE FROM THIS PAD TO THE BODY OF X1. IF NOT SUPPLIED WITH CRYSTAL.

REVISIONS				
ECO#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



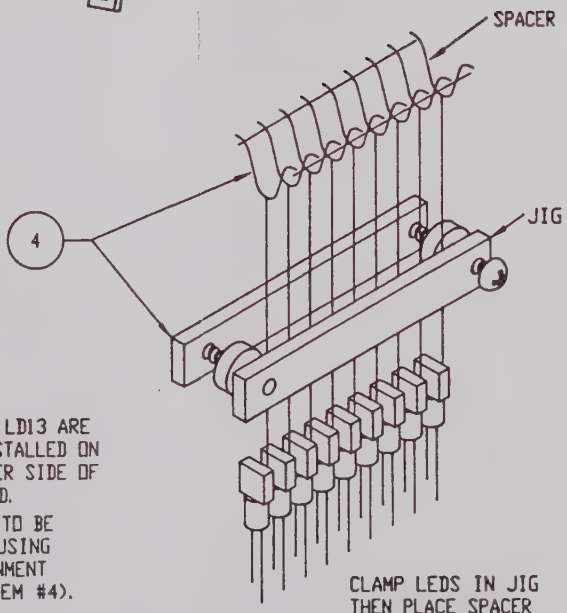
PCB AS SHOWN
USING A PERMANENT
ER, COLOR: BLACK





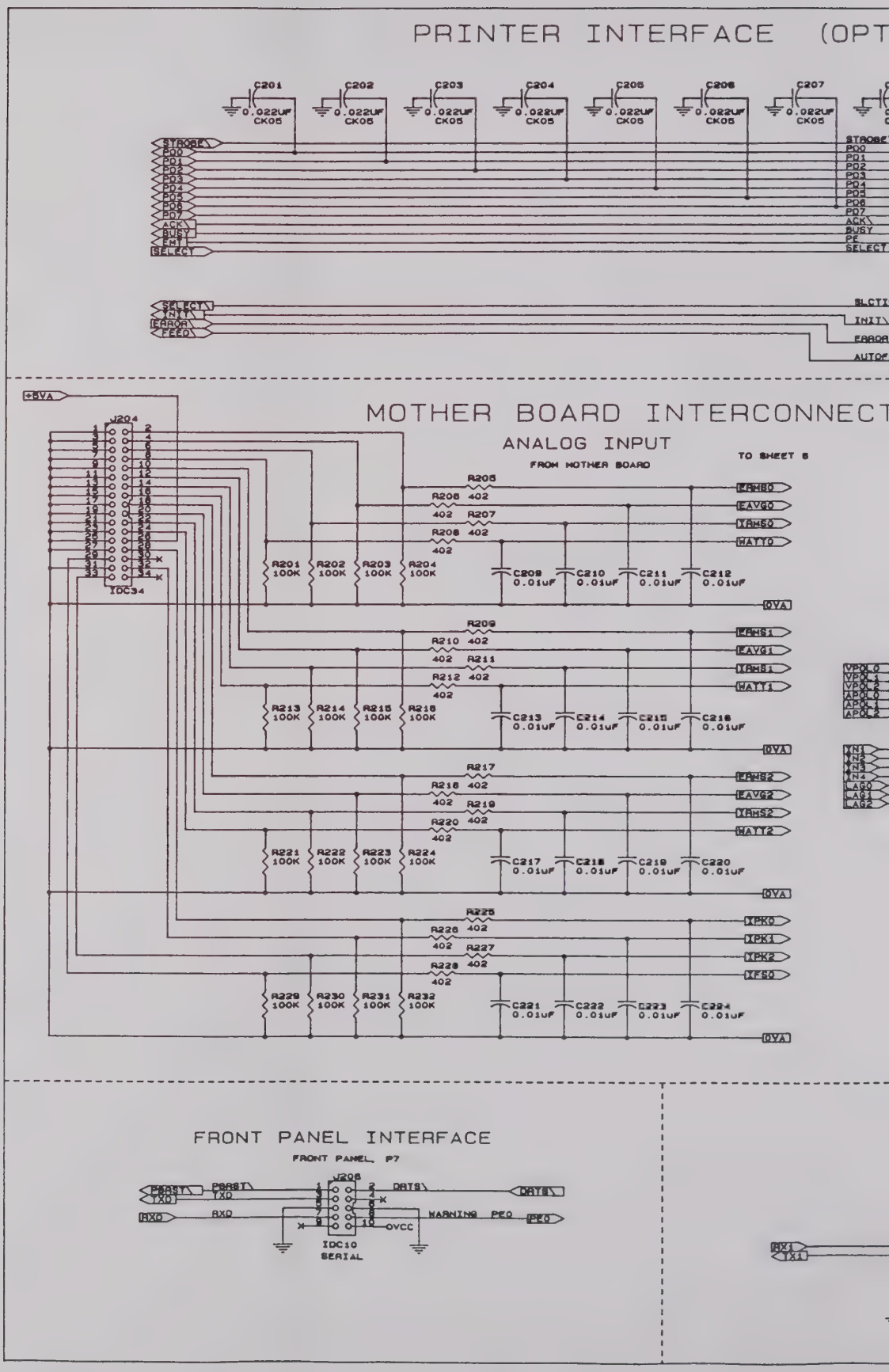
NOTE: LD3 THRU LD13 ARE TO BE INSTALLED ON THE SOLDER SIDE OF THE BOARD.

LEDS ARE TO BE ALIGNED USING THE ALIGNMENT TOOL (ITEM #4).

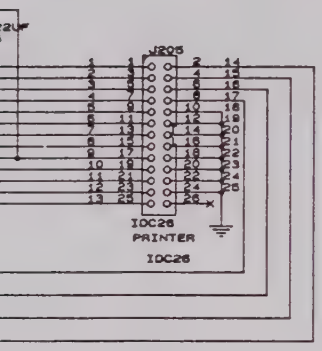


CLAMP LEDS IN JIG THEN PLACE SPACER IN BETWEEN LEDS TO SPACE THEM OUT.

ES: = ± 30' = ± .02 = ± .005	FINISH:	MATERIAL:		VALHALLA SCIENTIFIC 9955 MESA RIM RD. SAN DIEGO, CA 92121	
URR AND AK ALL P EDGES ORNERS			THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC, INC. AND EXCEPT FOR RIGHTS EXPRESSLY GRANTED TO THE UNITED STATES GOVERNMENT, VALHALLA SCIENTIFIC, INC. RESERVES ALL PATENT, SALE, PROPRIETARY, DESIGN, MANUFACTURING, USE AND REPRODUCTION RIGHTS THERETO.	TITLE P.C.B. ASSEMBLY- DISPLAY BOARD	
CHINED ACES ARE HAVE A NISH OF	SCALE: 1 : 1	STOCK NO. 30-00148		SHEET 1 OF 1	DRAWING NO. 2330-602 REV: D


PRINTER INTERFACE (OPT
C201
C202
C203
C204
C205
C206
C207
0.022UF
CK05
STROBE\
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
ACK\
BUSY
PE
SELECT
SELECT\
INIT\
FAULT\
FEED\
SLCTI
INITI\
FAULTI\
AUTOF
MOTHER BOARD INTERCONNECT
ANALOG INPUT
FROM MOTHER BOARD
TO SHEET 8
+8VA
J204
IDC34
R205
R206 402
R207
R208 402
R201 100K
R202 100K
R203 100K
R204 100K
C209 0.01uF
C210 0.01uF
C211 0.01uF
C212 0.01uF
VAMS0
VAVG0
VAMS0
VAYY0
0VA
R209
R210 402
R211
R212 402
R213 100K
R214 100K
R215 100K
R216 100K
C213 0.01uF
C214 0.01uF
C215 0.01uF
C216 0.01uF
VAMS1
VAVG1
VAMS1
VAYY1
VPOL0
VPOL1
VPOL2
APOL0
APOL1
APOL2
R217
R218 402
R219
R220 402
R221 100K
R222 100K
R223 100K
R224 100K
C217 0.01uF
C218 0.01uF
C219 0.01uF
C220 0.01uF
VAMS2
VAVG2
VAMS2
VAYY2
IN1
IN2
IN3
IN4
AG0
AG1
AG2
R225
R226 402
R227
R228 402
R229 100K
R230 100K
R231 100K
R232 100K
C221 0.01uF
C222 0.01uF
C223 0.01uF
C224 0.01uF
VPK0
VPK1
VPK2
VFS0
FRONT PANEL INTERFACE
FRONT PANEL P7
J206
P8RST
TXD
RXD
DRTS\
WARNING
PE0
0VCC
IDC10
SERIAL
RX1
TX1

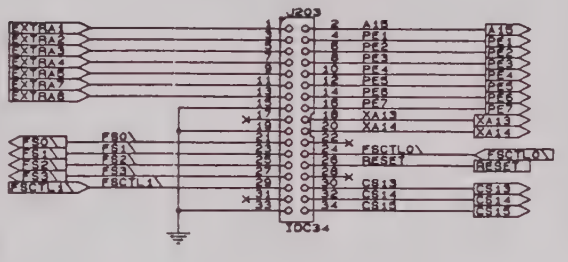
ON "PAR")



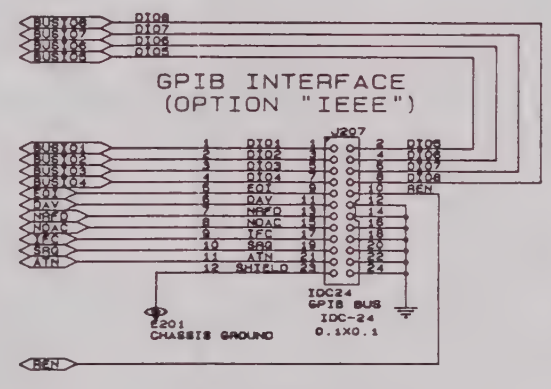
DIGITAL I/O
2330 SPARES

Hz	3	2	1	0
60	1	1	1	0
120	1	1	0	1
180	1	1	0	0
240	1	0	1	1
300	1	0	1	0
360	1	0	0	1
420	1	0	0	0
480	0	1	1	1

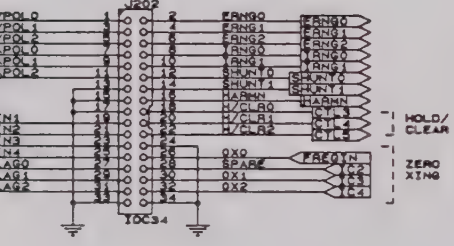
(THRU 0 0 0 0)



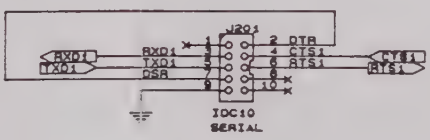
REAR PANEL INTERFACE



DIGITAL I/O

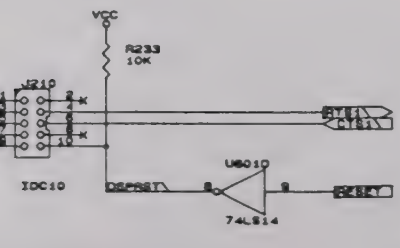


DTE RS232C PORT
(OPTION "RS232")

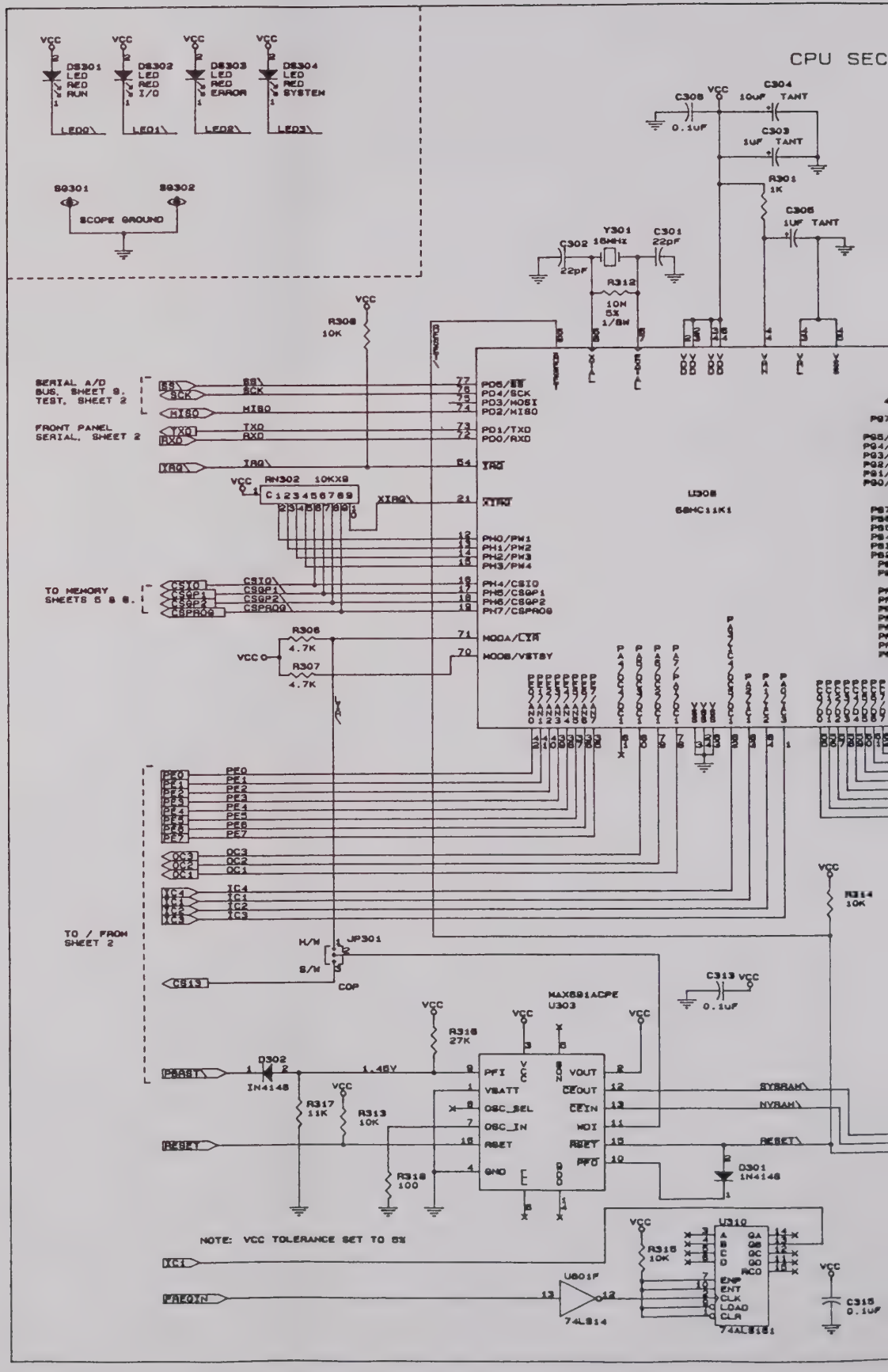


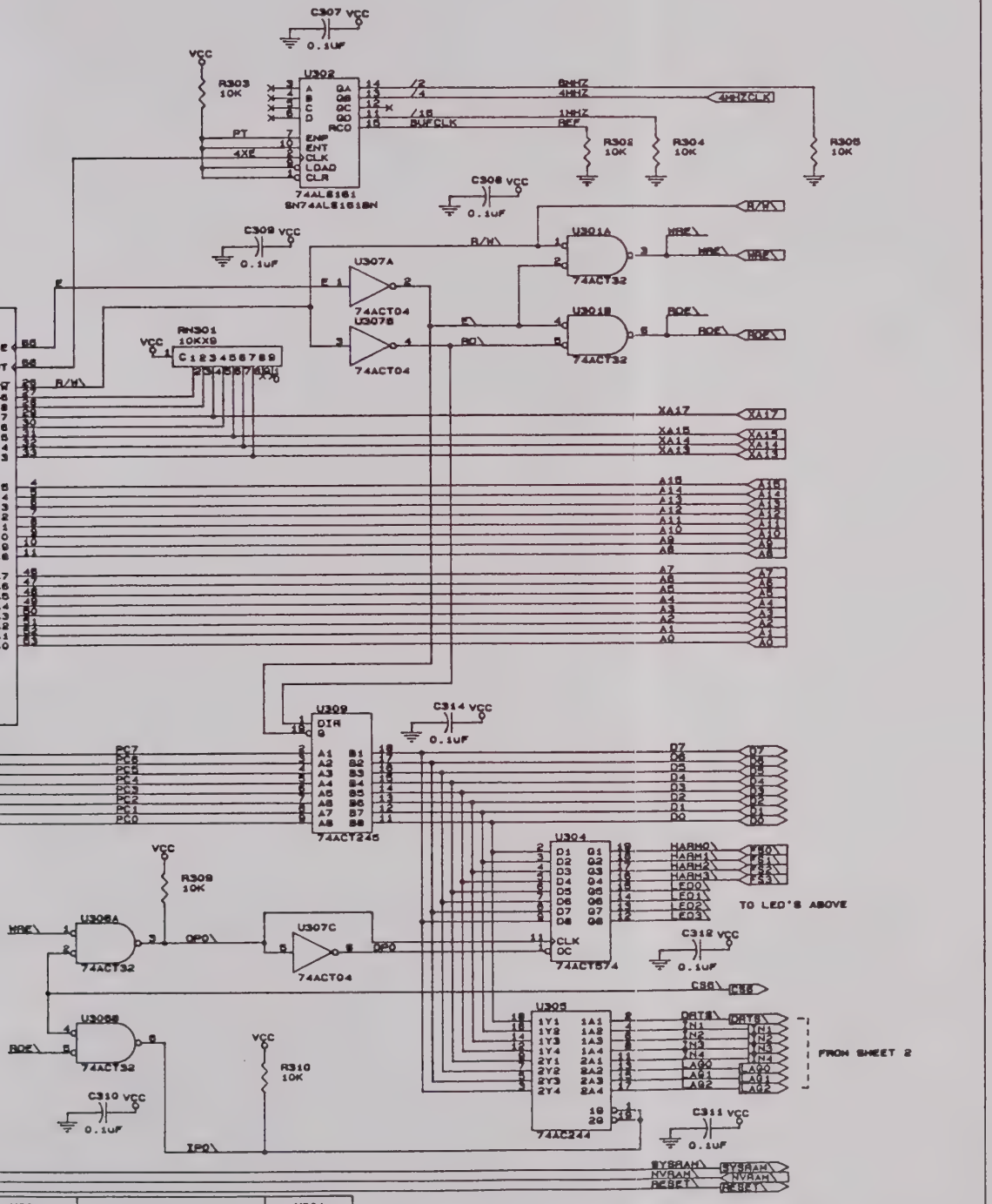
R201	----------	R233
J201	J208	J210
C201	----------	C224
FIRST USED	NOT USED	LAST USED

OSP CONNECTOR



INTERFACE SECTION	SCHEMATIC - MAIN MICROPROCESSOR BOARD			
	SIZE C	CAGE CODE	DWG NO 2330-074	REV D
September 8, 1995	SCALE		SHEET 2 OF 10	


CPU SEC
DS301 LED RED RUN
DS302 LED RED I/O
DS303 LED RED ERROR
DS304 LED RED SYSTEM
LED0\
LED1\
LED2\
LED3\
SO301
SO302
SCOPE GROUND
C308 0.1uF
C304 10uF TANT
C303 1uF TANT
R301 1K
C305 1uF TANT
Y301 16MHz
C301 22pF
C302 22pF
R312 10M 5% 1/8W
R308 10K
SERIAL A/D BUS, SHEET 9, TEST, SHEET 2
FRONT PANEL SERIAL, SHEET 2
SS\
SCK
MISO
TXD
RXD
IRQ\
RN302 10KX8
XIRQ\
PD5/SS\
PD4/SCK
PD3/MOSI
PD2/MISO
PD1/TXD
PD0/RXD
IRQ\
XIRQ\
U308
68HC11K1
PH0/PW1
PH1/PW2
PH2/PW3
PH3/PW4
TO MEMORY SHEETS 5 & 8.
CSIO\
CSGP1\
CSGP2\
CSPRO9\
PH4/CSIO
PH5/CSGP1
PH6/CSGP2
PH7/CSPRO9
R306 4.7K
R307 4.7K
MODA/LIR
MODB/VSTBY
PE0
PE1
PE2
PE3
PE4
PE5
PE6
PE7
OC3
OC2
OC1
IC4
IC1
IC2
IC3
TO / FROM SHEET 2
M/M
S/M
JP301
CS15\
COP
R314 10K
C313 0.1uF
MAX691ACPE
U303
R316 27K
D302 IN4148
PSENSE\
1.45V
R317 11K
R313 10K
R318 100
PFI
VBATT
OSC_SEL
OSC_IN
RESET
GND
VOUT
CEOUT
CEIN
WDI
RESET
PFO
SYSRAM\
NVRAM\
RESET\
D301 IN4148
NOTE: VCC TOLERANCE SET TO 5%
XC1
PAEQIN
U801F
74LS14
U310
R315 10K
ENP
ENT
CLK
LOAD
CLR
74ALS161
C315 0.1uF



Y301	----------	Y301
U301	----------	U310
TP301	----------	TP301
RN301	----------	RN302
R301	----------	R318
JP301	----------	JP301
J301	----------	J301
D8301	----------	D8304
D301	----------	D302
C301	----------	C315
FIRST USED	NOT USED	LAST USED

CPU SECTION

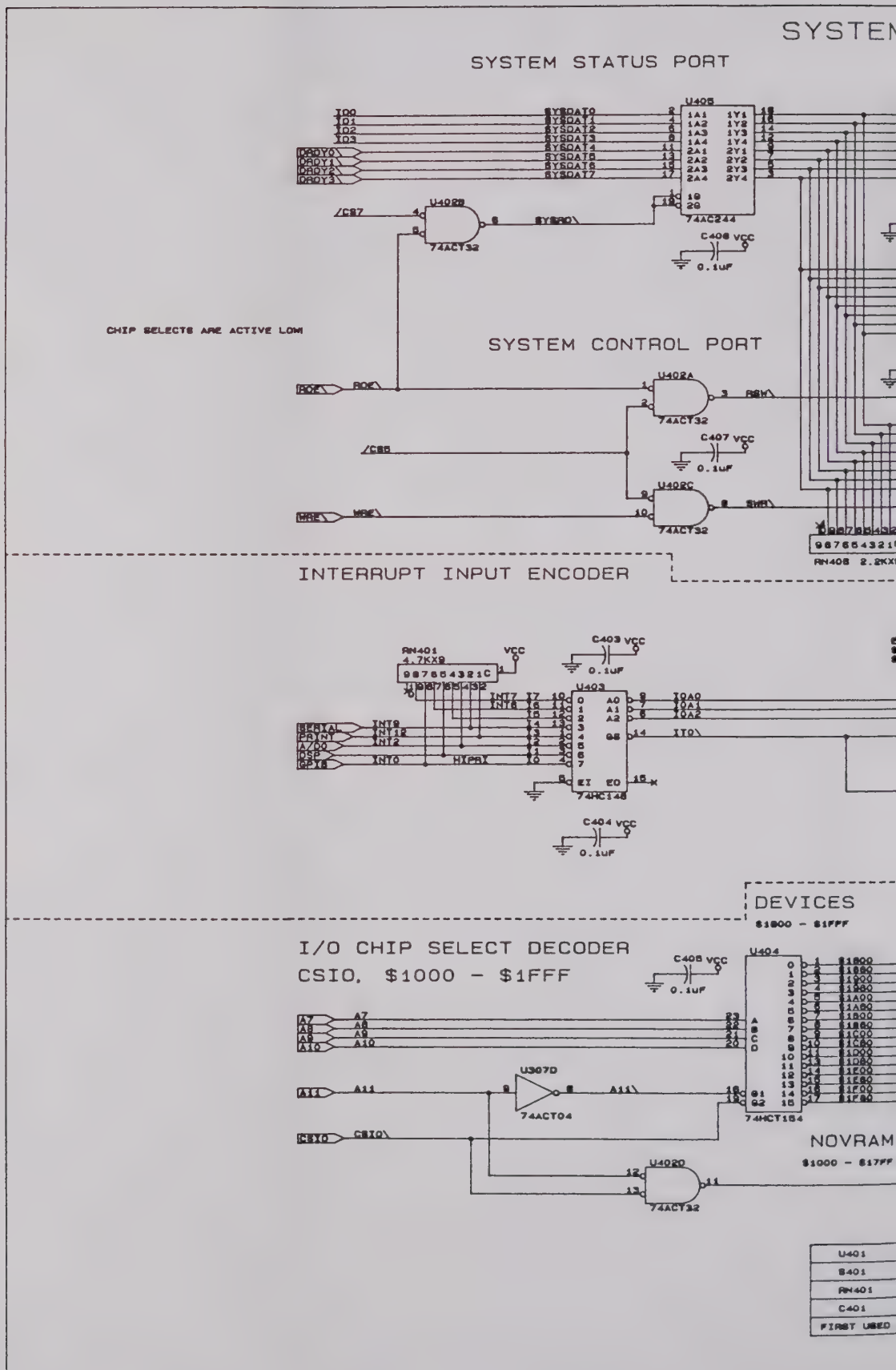
SCHEMATIC - MAIN MICROPROCESSOR BOARD

SIZE	CAGE CODE	DWG NO	REV
C		2330-074	D

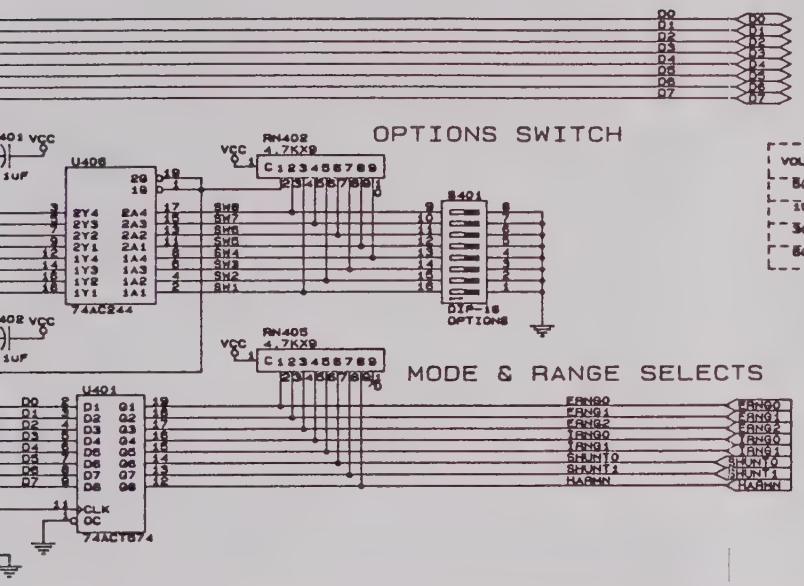
September 6, 1988

SCALE

SHEET 3 OF 10


SYSTEM STATUS PORT
U405
74AC244
U402B
74ACT32
C406 VCC
0.1uF
/CS7
CHIP SELECTS ARE ACTIVE LOW
SYSTEM CONTROL PORT
U402A
74ACT32
C407 VCC
0.1uF
/CS5
U402C
74ACT32
RN408 2.2KX
INTERRUPT INPUT ENCODER
RN401
4.7KX8
C403 VCC
0.1uF
U403
74HC148
C404 VCC
0.1uF
DEVICES
$1800 - $1FFF
I/O CHIP SELECT DECODER
CSIO, $1000 - $1FFF
C405 VCC
0.1uF
U404
74HCT154
U307D
74ACT04
U402D
74ACT32
NOVRAM
$1000 - $17FF
U401
S401
RN401
C401
FIRST USED

CONTROL



VOLTS	ERANGE2	ERANGE1	ERANGE0
50	0	1	1
150	1	0	1
300	1	1	0
500	1	1	1

AMPS	IRANGE1	IRANGE0
.2, 2, 20	0	0
.5, 5, 50	0	1
1, 10, 100	1	1

SHUNT	SHUNT1	SHUNT0
1 AMP	0	0
10 A	0	1
100A	1	0

OED INTERRUPT OUTPUT:
= HIGHEST PRIORITY
= LOWEST PRIORITY.

ID0
ID1
ID2
ID3

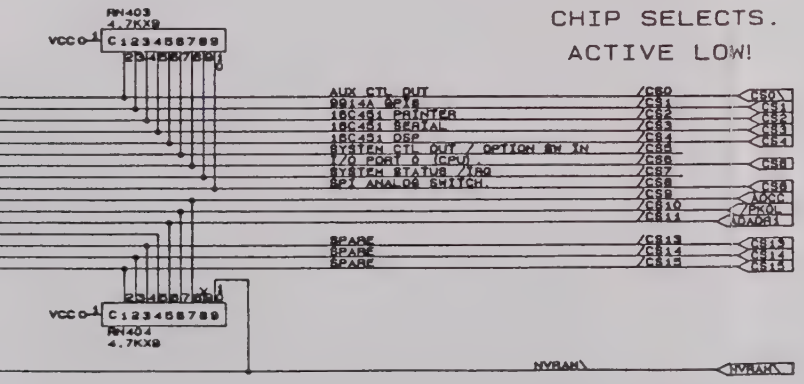
TO SYSTEM STATUS PORT (ABOVE LEFT)

C408 VCC
0.1uF

IRQ\

TO CPU, SHEET 3

TO SYSTEM STATUS PORT (ABOVE LEFT)

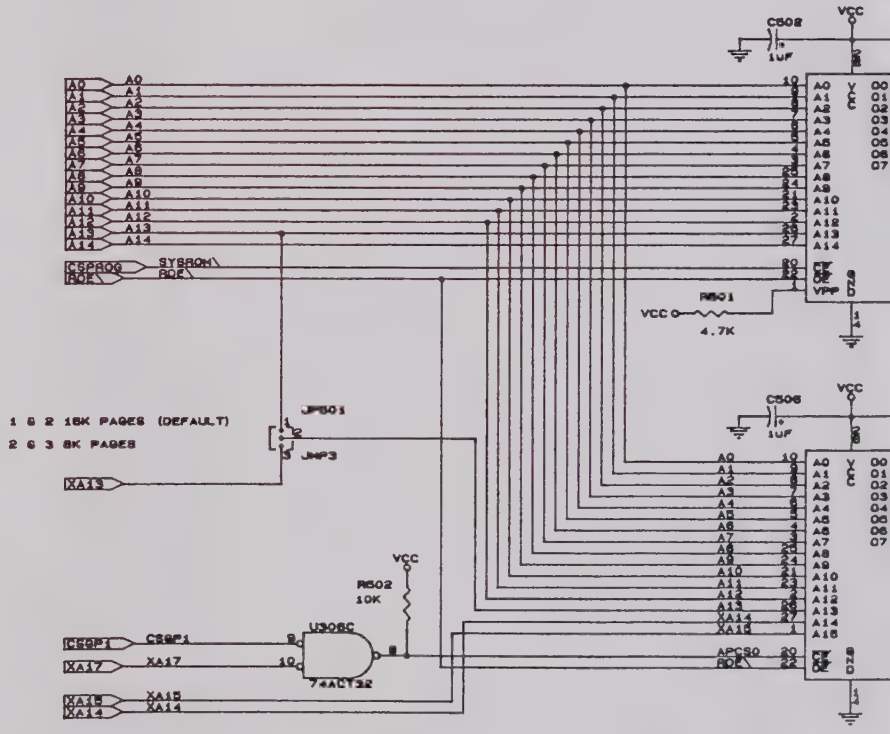


NON-VOLATILE RAM, SHEET 3.

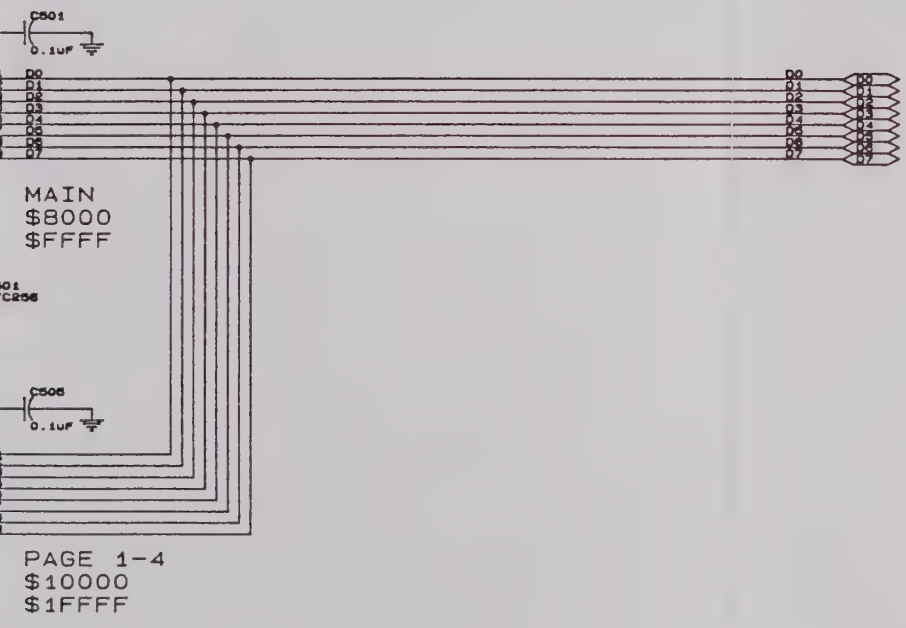
	U406
	S401
	RN406
	C408
NOT USED	LAST USED

SYSTEM CONTROL SECTION	SCHEMATIC - MAIN MICROPROCESSOR BOARD
August 29, 1995	SIZE C; CAGE CODE; DWG NO 2330-074; REV D; SCALE; SHEET 4 OF 10

CMOS E
32KX


C502
1UF
VCC
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
CSPROG
ROE
SYSROM\
ROE\
R501
4.7K
VPP
1 & 2 16K PAGES (DEFAULT)
2 & 3 8K PAGES
JP501
JMP3
XA13
C506
R502
10K
U308C
CSGP1
XA17
XA15
XA14
74ACT32
APCS0
ROE\

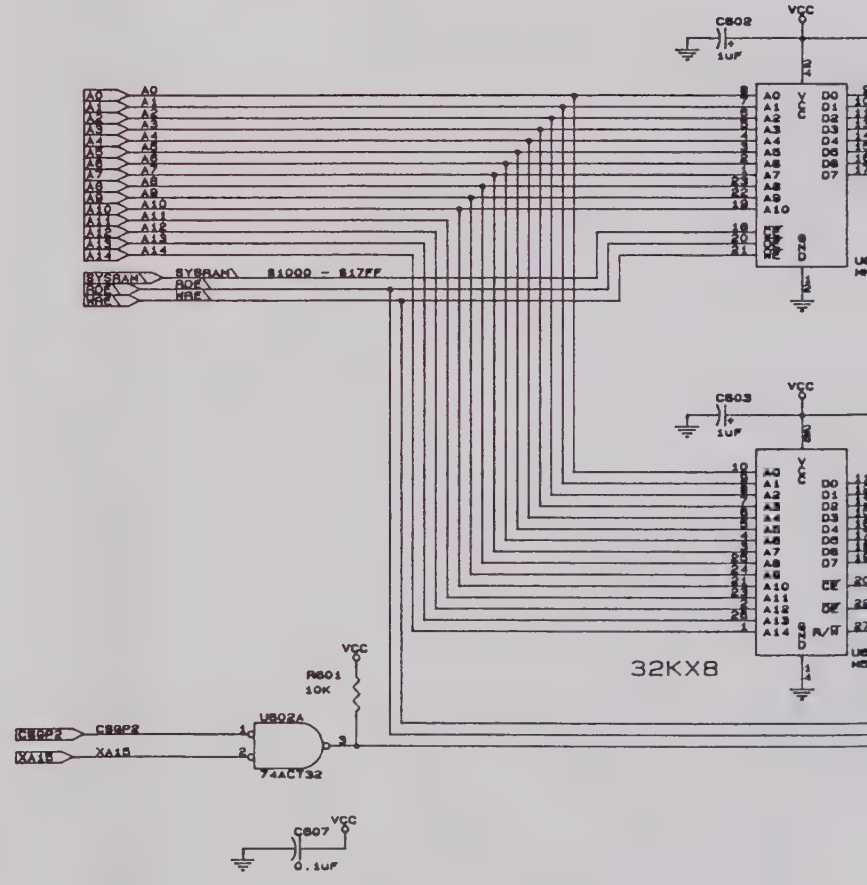
ROM

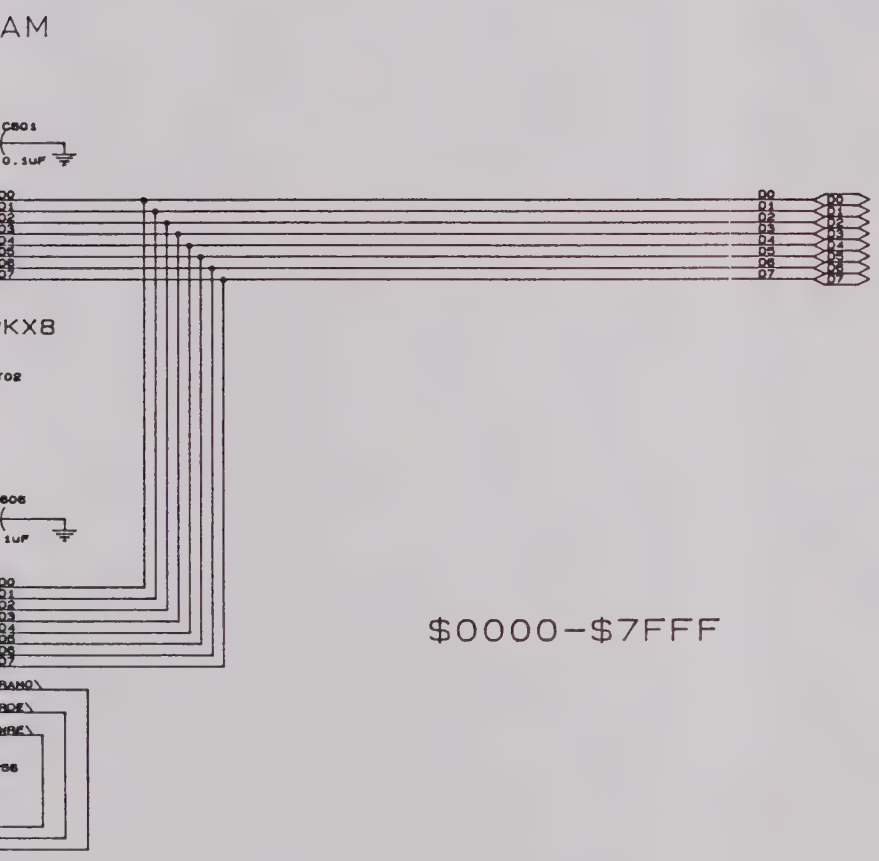


U501	----------	U502
R501	----------	R502
JP501	----------	JP501
C501	C503 C504	C506
FIRST USED	NOT USED	LAST USED

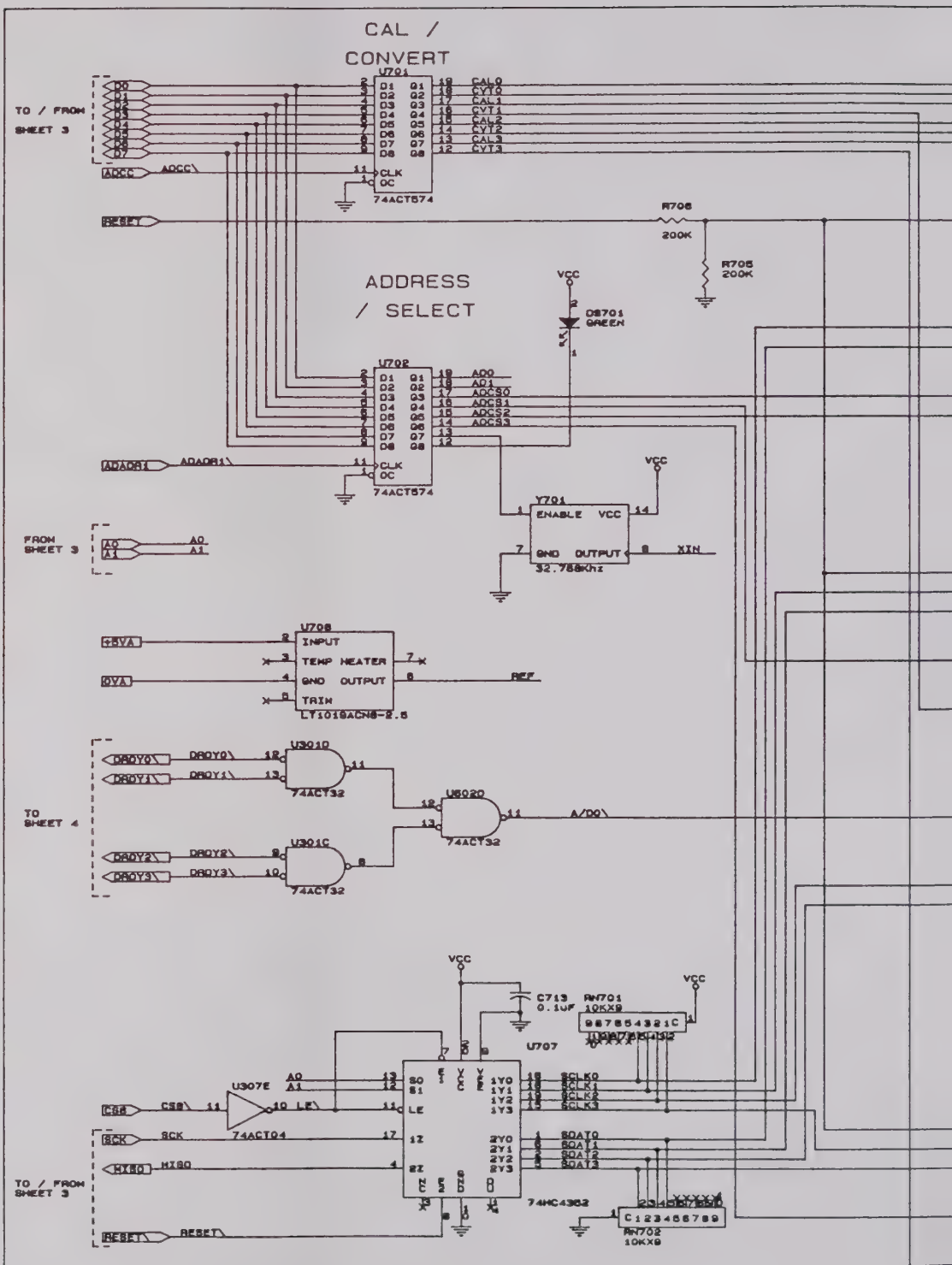
MAIN ROM	SCHEMATIC - MAIN MICROPROCESSOR BOARD			
	SIZE C	CAGE CODE	DWG NO 2330-074	REV D
August 29, 1995	SCALE		SHEET 5 OF 10	

CMOS

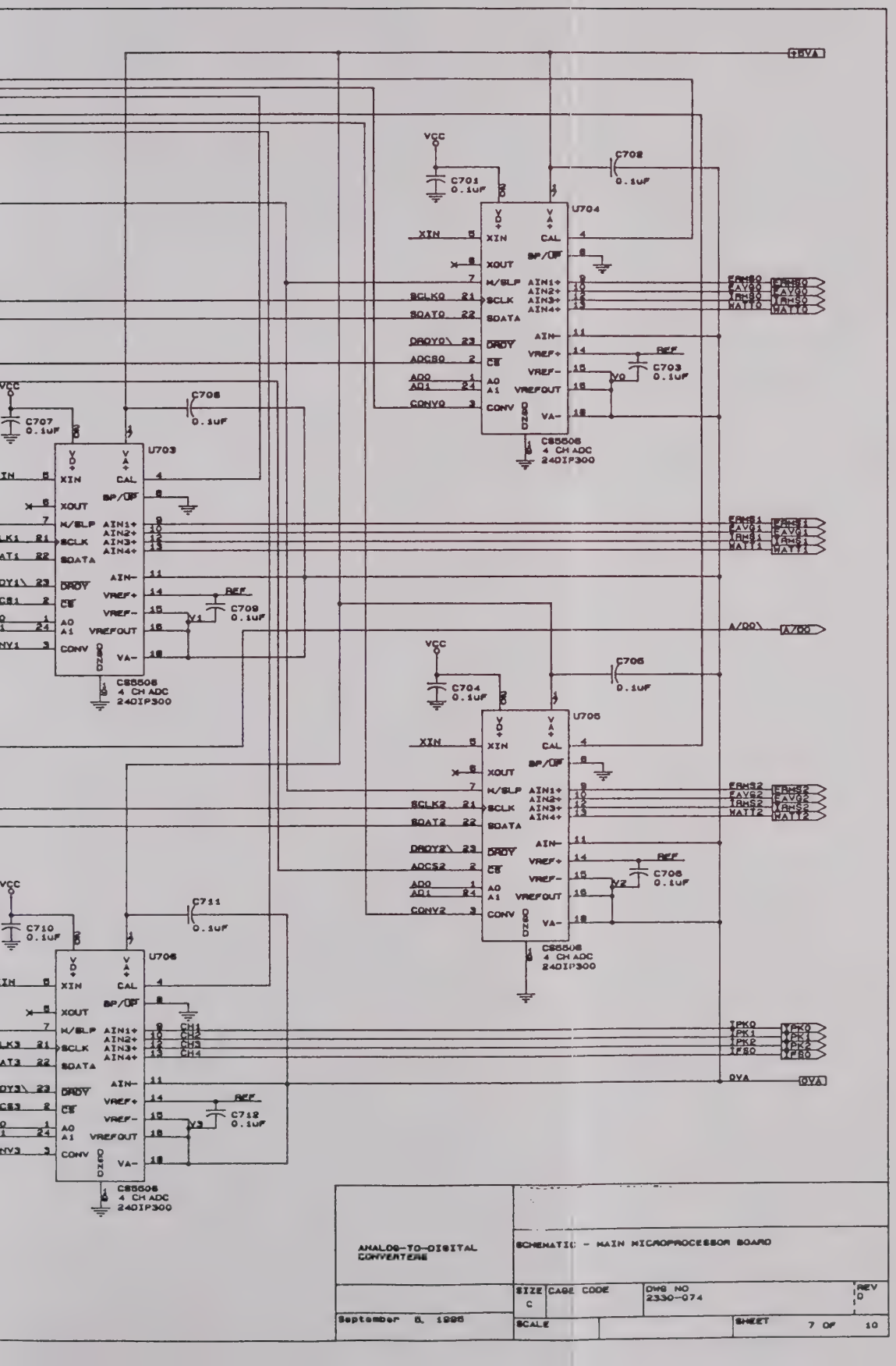

C802
1UF
VCC
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
SYSRAM\
ROE\
RWE\
$1000 - $17FF
C803
1UF
32KX8
R801
10K
U802A
74ACT32
C807
0.1UF



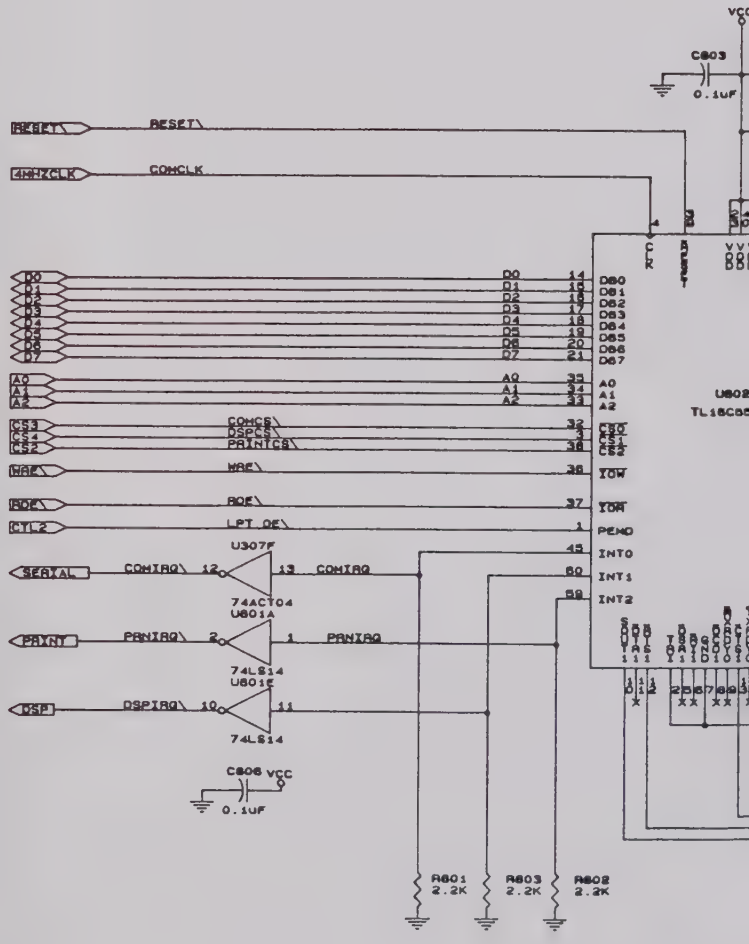
STATIC RAM	SCHEMATIC - MAIN MICROPROCESSOR BOARD			
	SIZE C	CAGE CODE	DWG NO 2330-074	REV D
August 22, 1986	SCALE		SHEET 6 OF 10	



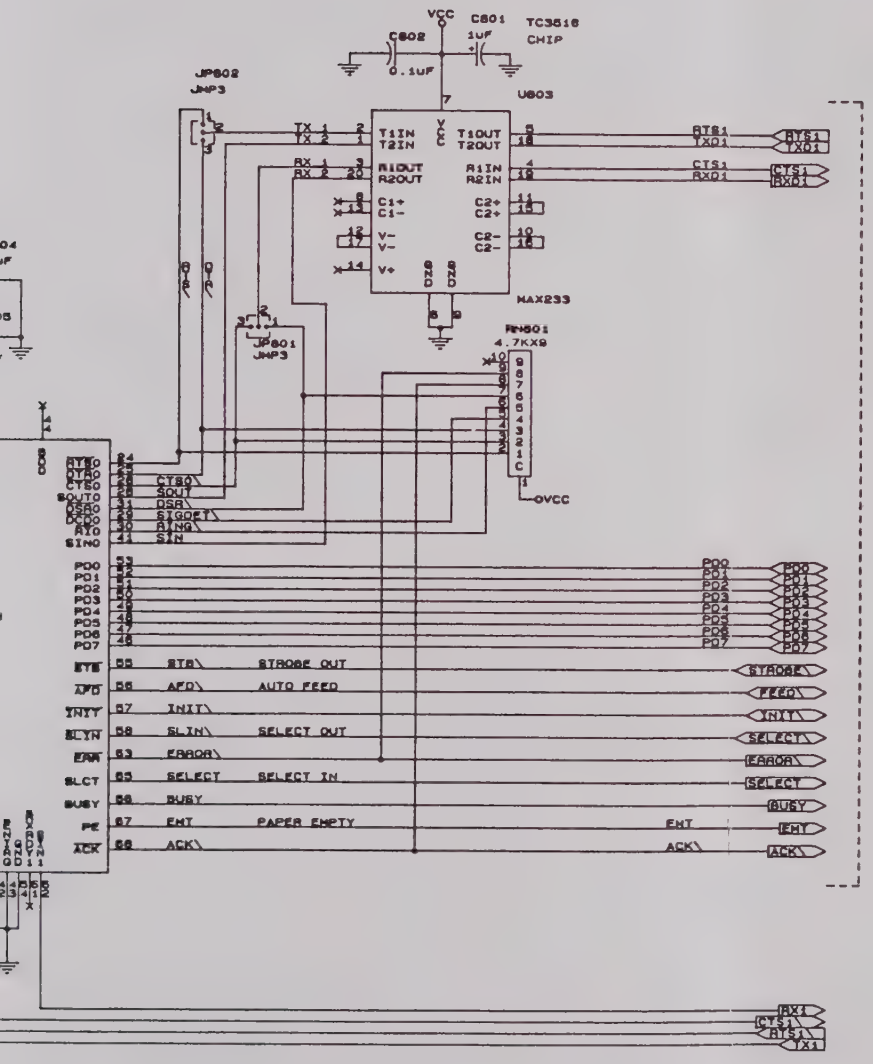
Y701	----------	Y701
U701	----------	U707
RN701	----------	RN702
R701	----------	R706
J701	----------	J702
D8701	----------	D8701
C701	----------	C713
FIRST USED	NOT USED	LAST USED


+5VA
VCC
C701 0.1uF
C702 0.1uF
U704
XIN
CAL
BP/UP
XOUT
M/SLP
AIN1+
AIN2+
AIN3+
AIN4+
SCLK0
SCLK
SDATA0
SDATA
DRDY0\
DRDY
ADCS0
CS
AD0
AD1
A0
A1
CONV0
CONV
AIN-
VREF+
VREF-
VREFOUT
VA-
REF
C703 0.1uF
V0
CS5508 4 CH ADC 24DIP300
FRMS0
FAVG0
FAMS0
WATT0
C706 0.1uF
C707 0.1uF
U703
DRDY1\
ADCS1
CONV1
C709 0.1uF
V1
FRMS1
FAVG1
FAMS1
WATT1
A/D0\
A/D0
C704 0.1uF
C705 0.1uF
U705
SCLK2
SDATA2
DRDY2\
ADCS2
CONV2
C708 0.1uF
V2
FRMS2
FAVG2
FAMS2
WATT2
C710 0.1uF
C711 0.1uF
U706
SCLK3
SDATA3
DRDY3\
ADCS3
CONV3
C712 0.1uF
V3
CH1
CH2
CH3
CH4
IPK0
IPK1
IPK2
IFS0
0VA
ANALOG-TO-DIGITAL CONVERTERS
SCHEMATIC - MAIN MICROPROCESSOR BOARD
SIZE C
CAGE CODE
DWG NO 2330-074
REV D
September 6, 1995
SCALE
SHEET 7 OF 10

SERIAL / PA


RESET
RESET\
4MHZCLK
COMCLK
C803
0.1uF
D0
D1
D2
D3
D4
D5
D6
D7
A0
A1
A2
CS3
CS4
CS2
WR\
RD\
CTL2
COMCS\
DSPCS\
PRINTCS\
WR\
RD\
LPT_OE\
SERIAL
PAYNT
DSP
COMIRQ\
PANIRQ\
DSPIRQ\
U307F
74ACT04
U801A
74LS14
U801E
74LS14
C808 VCC
0.1uF
R801
2.2K
R803
2.2K
R802
2.2K
U802
TL16C55
INT0
INT1
INT2
IOW
IOR
PEMD

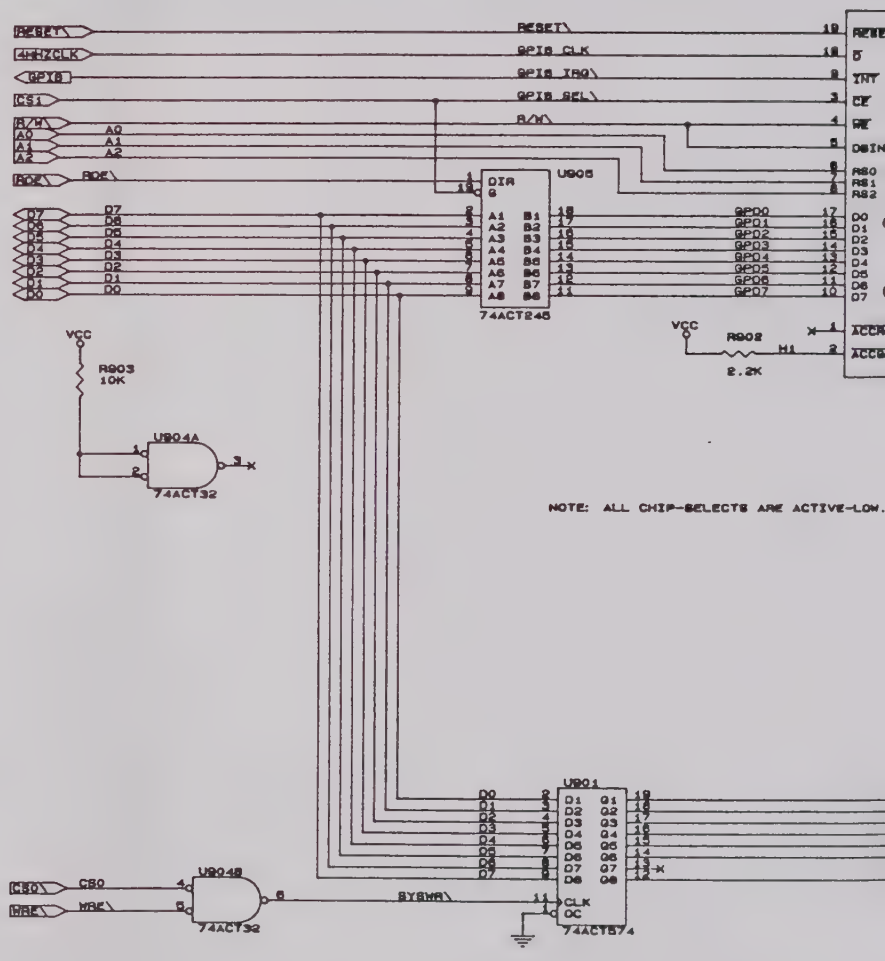
ALLEL OPTION



	----------	U803
	----------	RN801
	----------	R802
	----------	JP802
	----------	C808
	NOT USED	LAST USED

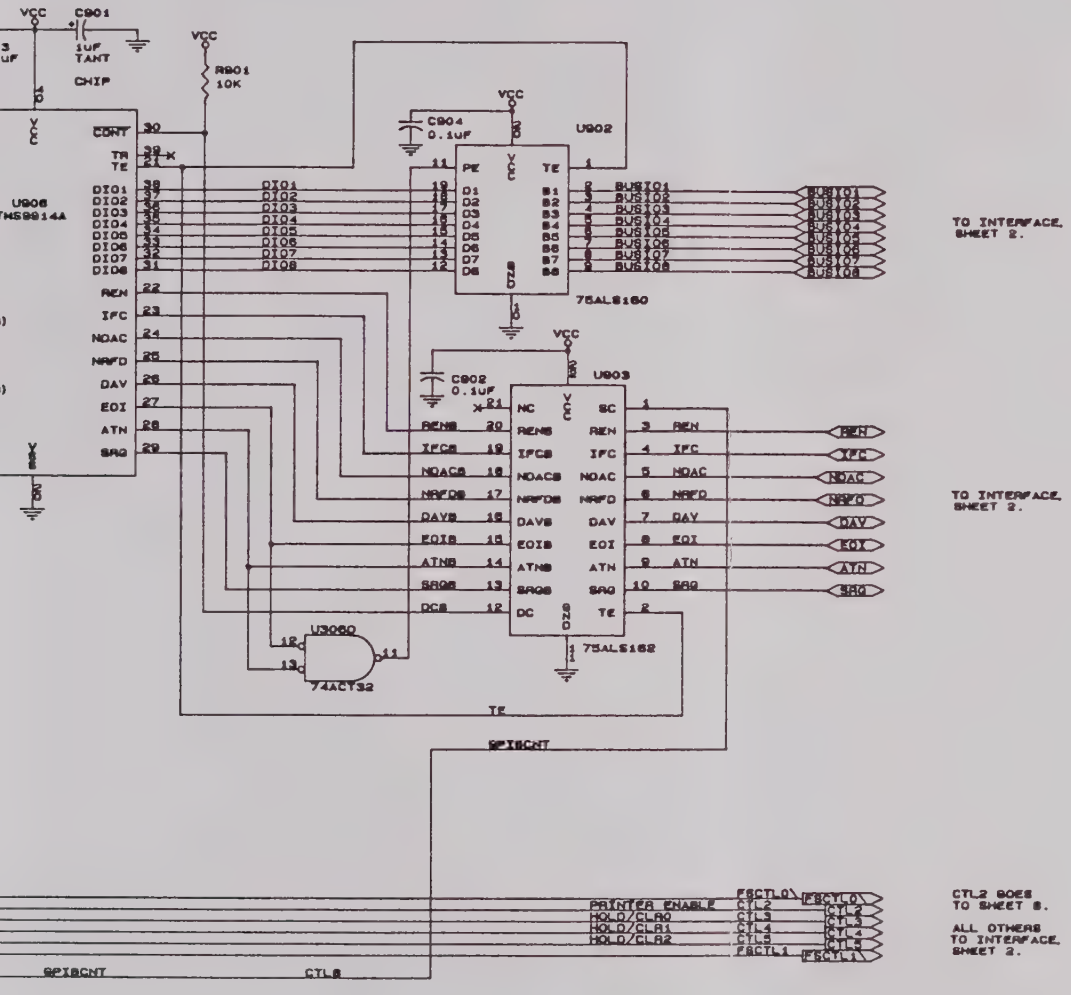
PRINTER INTERFACE				
	SCHEMATIC - MAIN MICROPROCESSOR BOARD			
	SIZE C	CAGE CODE	DWG NO 2330-074	REV D
September 6, 1995	SCALE		SHEET 8 OF 10	

IEEE-488.2 (GPIB)



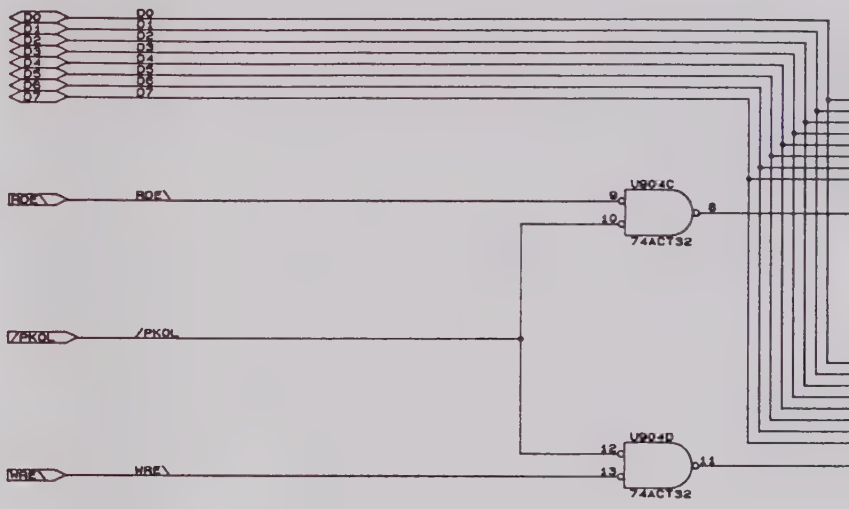
U901	
TP901	
R901	
C901	
FIRST USED	

INTERFACE OPTION



U805	U806
	TP801
	R803
	C901
NOT USED	LAST USED

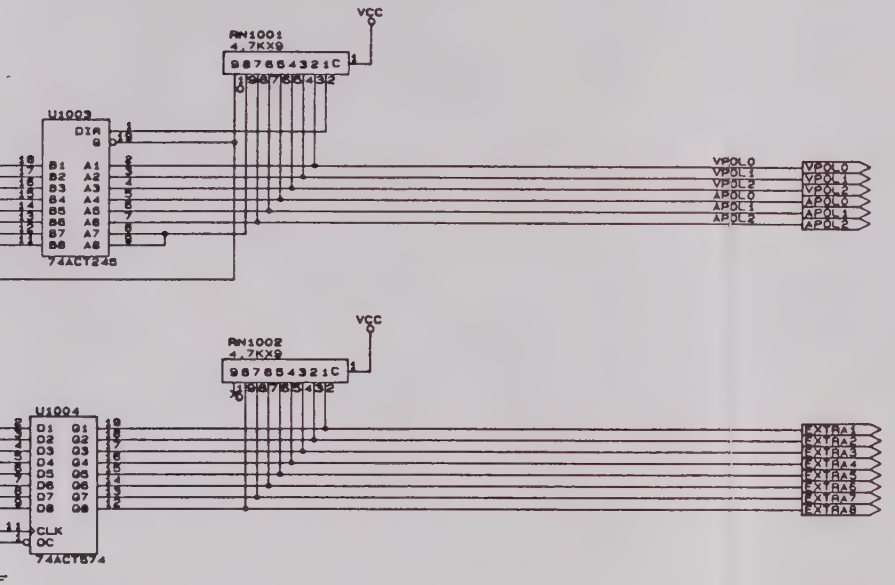
IEEE-488.2 INTERFACE	SCHEMATIC - MAIN MICROPROCESSOR BOARD			
	SIZE C	CAGE CODE	DWG NO 2330-074	REV 0
August 29, 1995	SCALE		SHEET 9 OF 10	



SPARES:

NOTES:

U1003
RN1001
R1001
J1001
C1001
FIRST USE



	U1004
	RN1002
	R1001
	J1001
	C1003
NOT USED	LAST USED

OVERLOAD SIGNALS
G
SPARE BUFFERS

SCHEMATIC - MAIN MICROPROCESSOR BOARD

SIZE	CAGE CODE	DWG NO	REV
C		2330-074	D

September 1, 1995

SCALE

SHEET 10 OF 10

NOTES: UNLESS OTHERWISE SPECIFIED

1. SEE SEPARATE PARTS LIST.

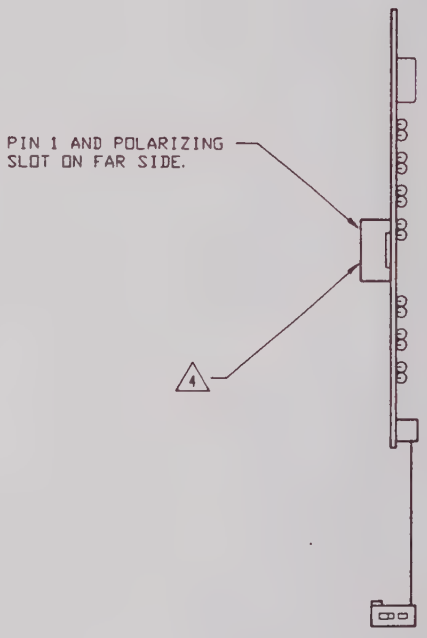
2. INSTALL SHORTING PLUGS ITEM (2) AS FOLLOWS:

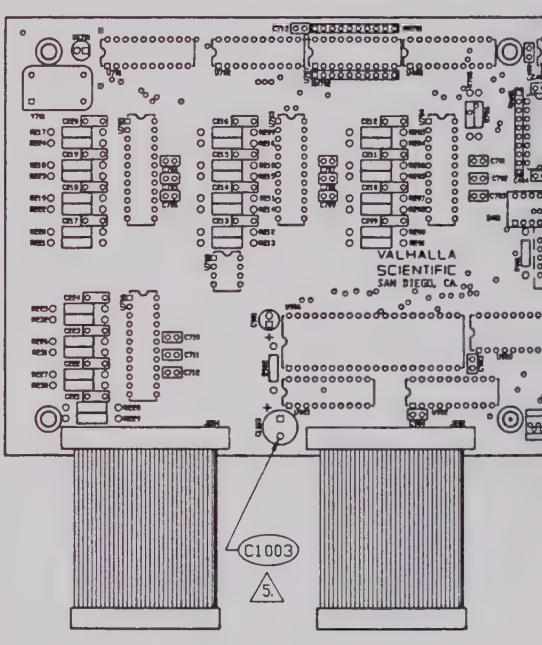
   JP301 PINS 2 & 3.
   JP501 PINS 1 & 2.
   JP801 PINS 1 & 2.
   JP802 PINS 2 & 3.

3. TRIM PINS 3,4,5, AND 6, OF S401 FLUSH WITH PCB ON SOLDER SIDE.

4. INSTALL J210 ON SOLDER SIDE OF BOARD AS SHOWN.

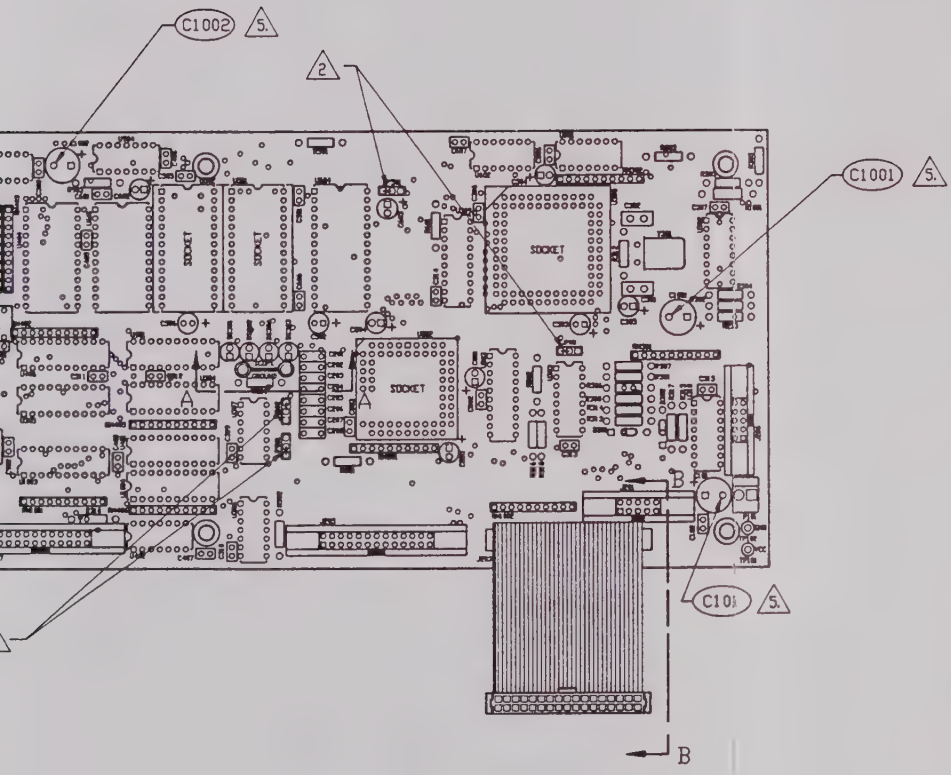
5. INSTALL WITH POSITIVE (+) LEAD AT ROUND PAD.





VI

REVISIONS				
ECO#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED



VIEW B-B

1

0.25

A-A

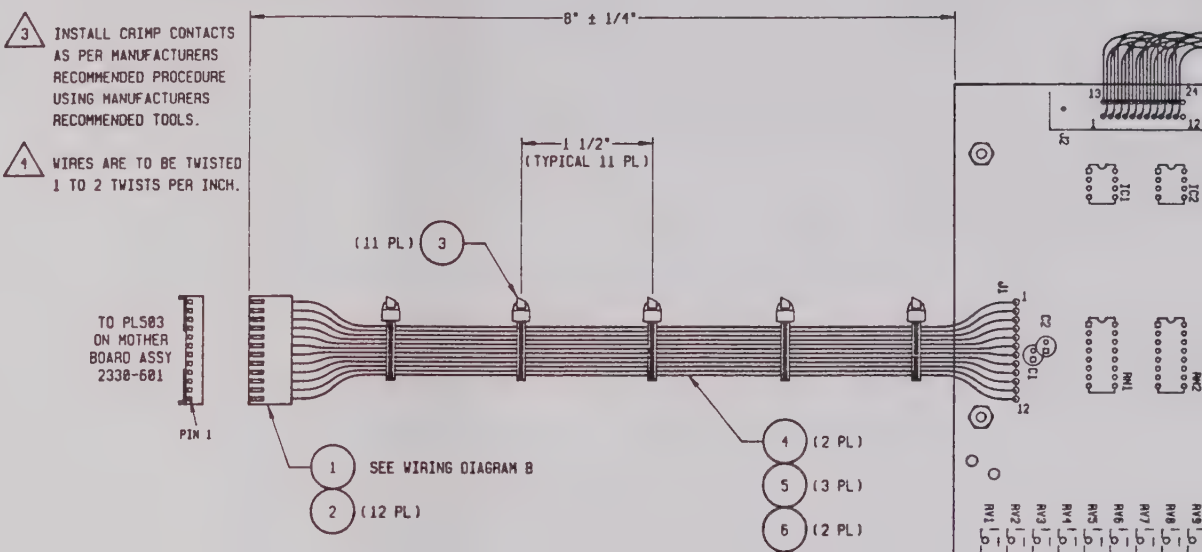
TOLERANCES: X = ±30' .XX = ±.02 .XXX = ±.010	FINISH:	MATERIAL:	VALHALLA SCIENTIFIC 9955 MESA RIM RD. SAN DIEGO, CA 92121
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS		THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC INC. AND FILED FOR RIGHTS EXPRESSLY RESERVED UNDER THE LAWS OF THE UNITED STATES GOVERNMENT. VALHALLA SCIENTIFIC INC. RESERVES ALL PATENT, SALE, PROPRIETARY, DESIGN, MANUFACTURING, USE AND REPRODUCTION RIGHTS THEREIN.	TITLE: ASSEMBLY- MICROPROCESSOR BOARD
MACHINED SURFACES ARE TO HAVE A FINISH OF	SCALE: 1 : 1	STOCK NO: 30-00150	SHEET 1 OF 1 · DRAWING NO: 2330-604 · REV: G

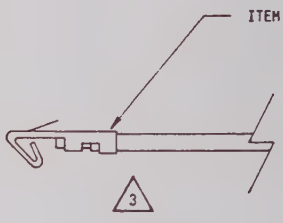
NOTES: Unless Otherwise Specified

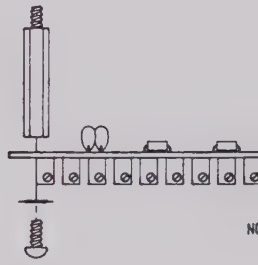
1. SEE SEPARATE PARTS LIST
2. BAG AND TAG WITH DRAWING NUMBER. STOCK NUMBER, AND CURRENT REVISION LETTER.

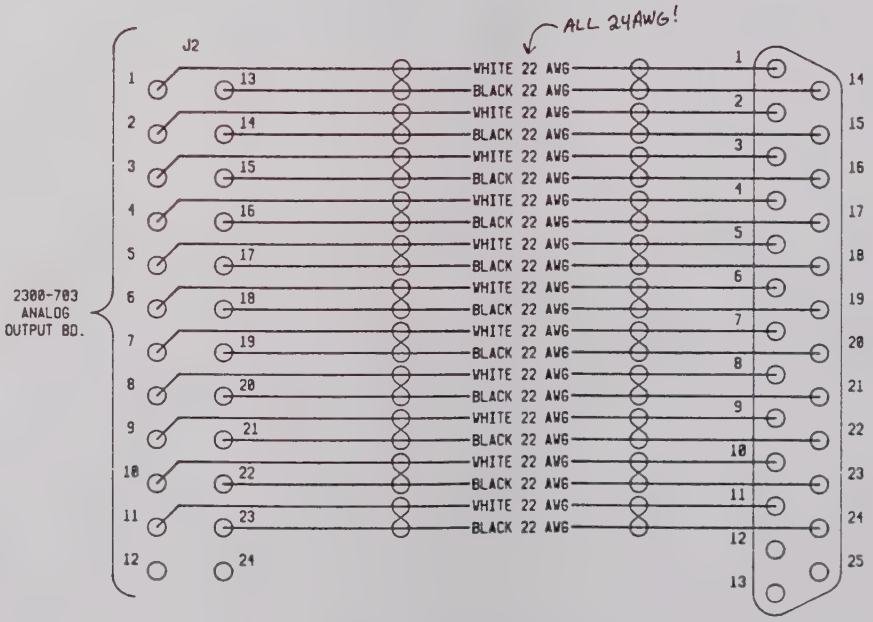
△3 INSTALL CRIMP CONTACTS AS PER MANUFACTURERS RECOMMENDED PROCEDURE USING MANUFACTURERS RECOMMENDED TOOLS.

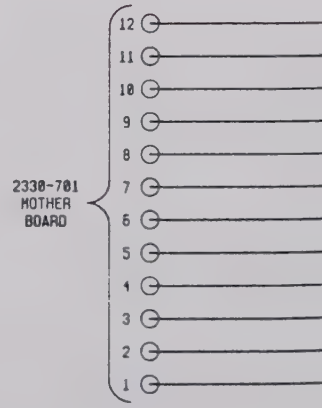
△4 WIRES ARE TO BE TWISTED 1 TO 2 TWISTS PER INCH.





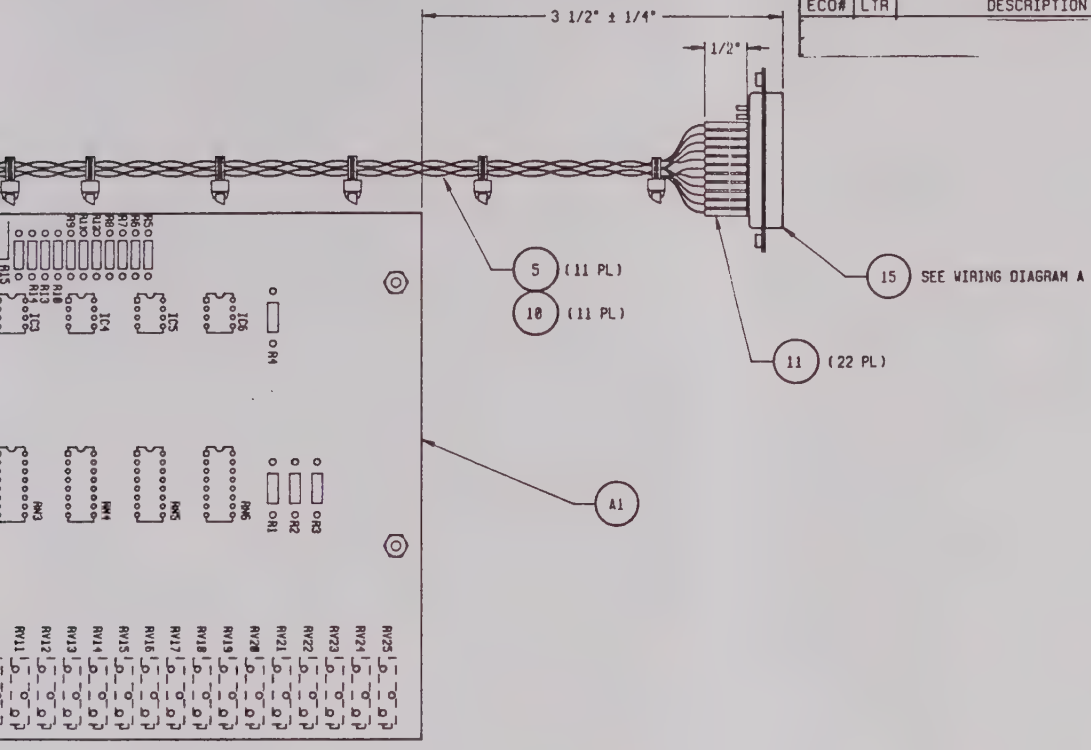


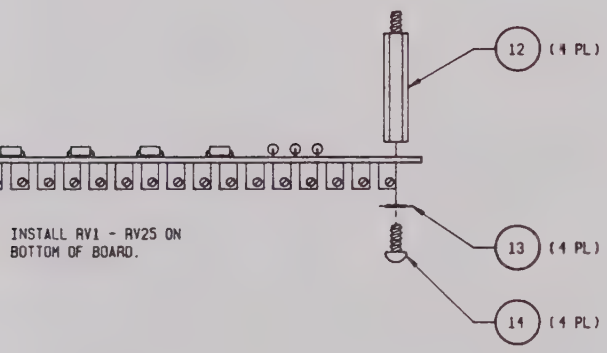




△4 WIRING DIAGRAM A

REVISIONS				
ECO#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED





INSTALL RV1 - RV25 ON BOTTOM OF BOARD.

ALL 22AWG!

BLACK 18 AWG	1	2300-703 ANALOG OUTPUT BD.
GREEN 18 AWG	2	
RED 18 AWG	3	
ORANGE 18 AWG	4	
ORANGE 18 AWG	5	
BROWN 18 AWG	6	
BROWN 18 AWG	7	
WHITE 18 AWG	8	
WHITE 18 AWG	9	
WHITE 18 AWG	10	
YELLOW 18 AWG	11	
YELLOW 18 AWG	12	

WIRING DIAGRAM B

TOLERANCES: X = ±30' .XX = ±.02 .XXX = ±.005

DEBURR AND BREAK ALL SHARP EDGES AND CORNERS

MACHINED SURFACES ARE TO HAVE A FINISH OF

FINISH:

MATERIAL:

SCALE: 1 : 1

STOCK NO.

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VALHALLA SCIENTIFIC
9955 MESA RIM RD. SAN DIEGO, CA 92121

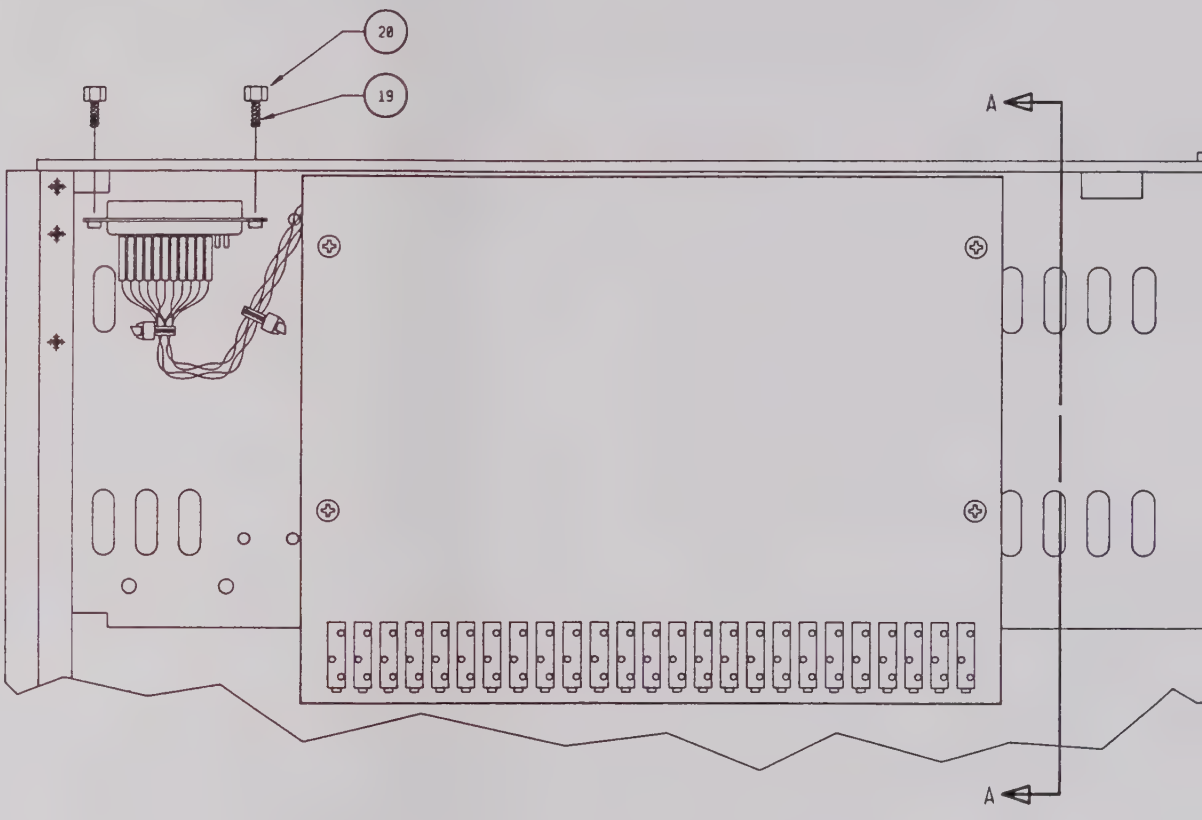
TITLE: ASSEMBLY- OPTION "IOX"

SHEET 1 OF 2

DRAWING NO. 2330-403

REV: B

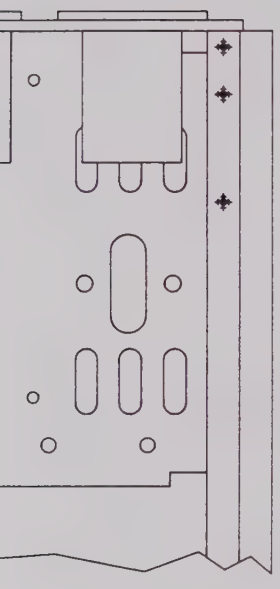
NOTES: Unless Otherwise Specified

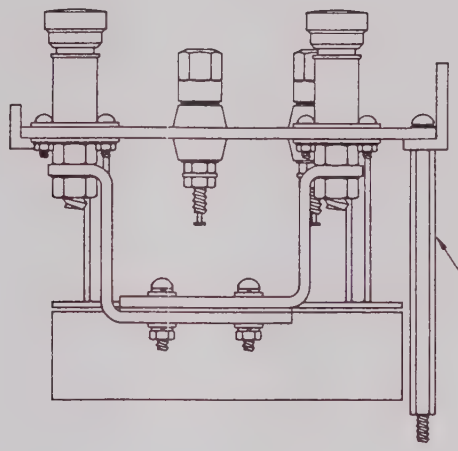


BOTTOM VIEW OF 2330 WITH BOTTOM COVER AND BEZEL REMOVED

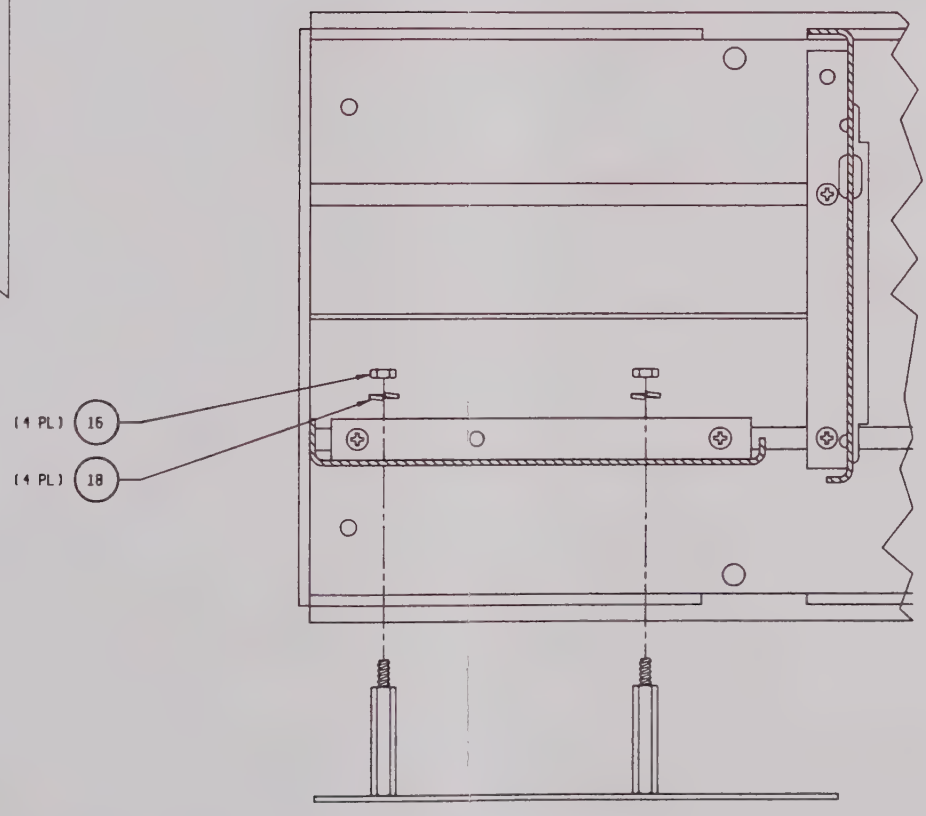
REVISIONS				
ECR#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED

SEE SHEET 1 FOR ALL REVISIONS





NOTE: SHUNTS MUST BE REMOVED TO MOUNT IOX BOARD.



SECTION A-A

TOLERANCES: X = ±30' .XX = ±.02 .XXX = ±.005	FINISH:	MATERIAL:	
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS			
MACHINED SURFACES ARE TO HAVE A FINISH OF	SCALE: 1 : 1	STOCK NO.	

THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF VALHALLA SCIENTIFIC INC. AND EXCEPT FOR RIGHTS EXPRESSLY GRANTED TO THE UNITED STATES GOVERNMENT VALHALLA SCIENTIFIC INC. RESERVES ALL PATENT, SALE, PROPRIETARY DESIGN, MANUFACTURING USE AND REPRODUCTION RIGHTS THERETO.

VALHALLA SCIENTIFIC

9955 MESA RIM RD. SAN DIEGO, CA 92121

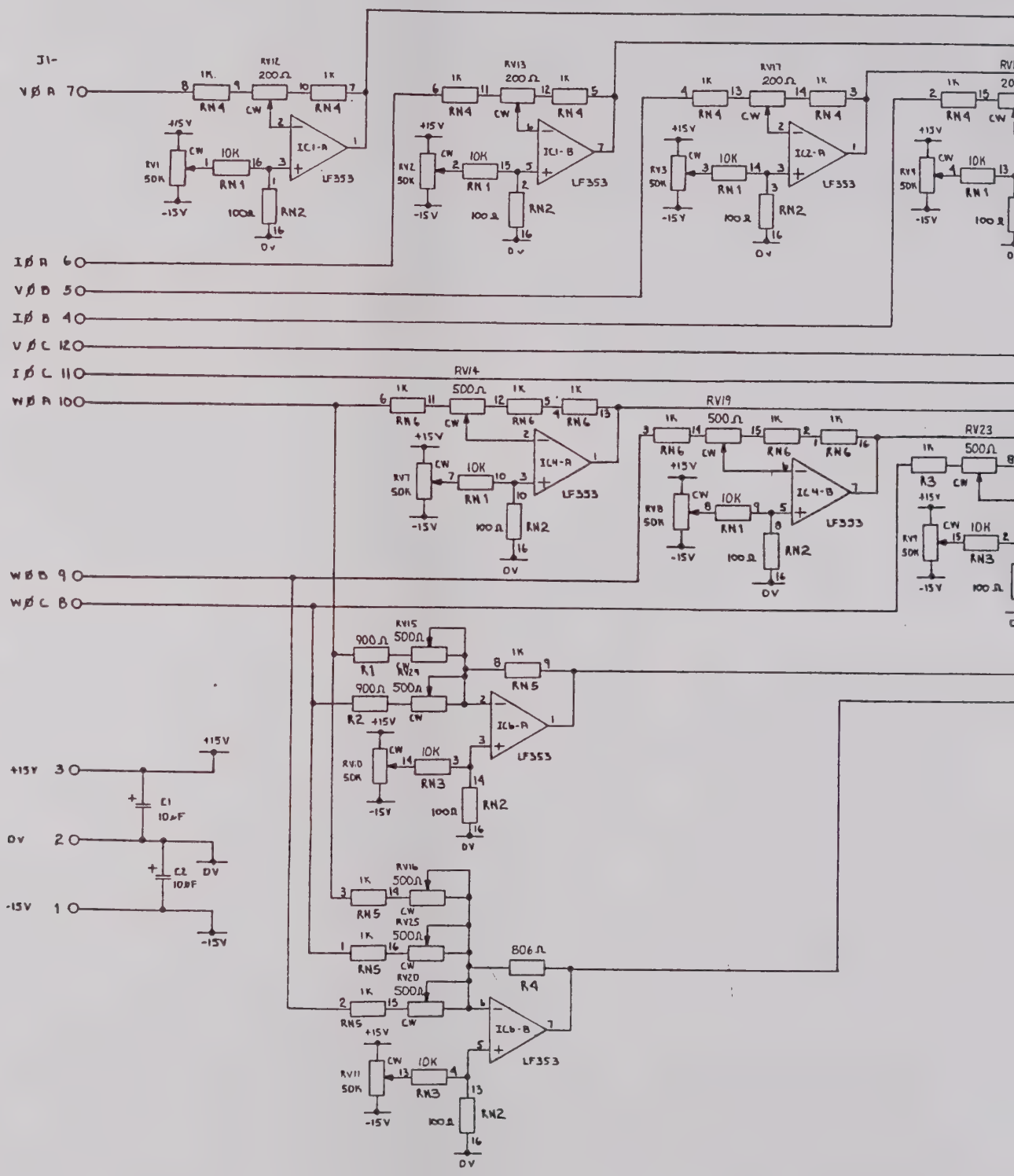
TITLE: ASSEMBLY- OPTION "IOX"

SHEET 2 OF 2

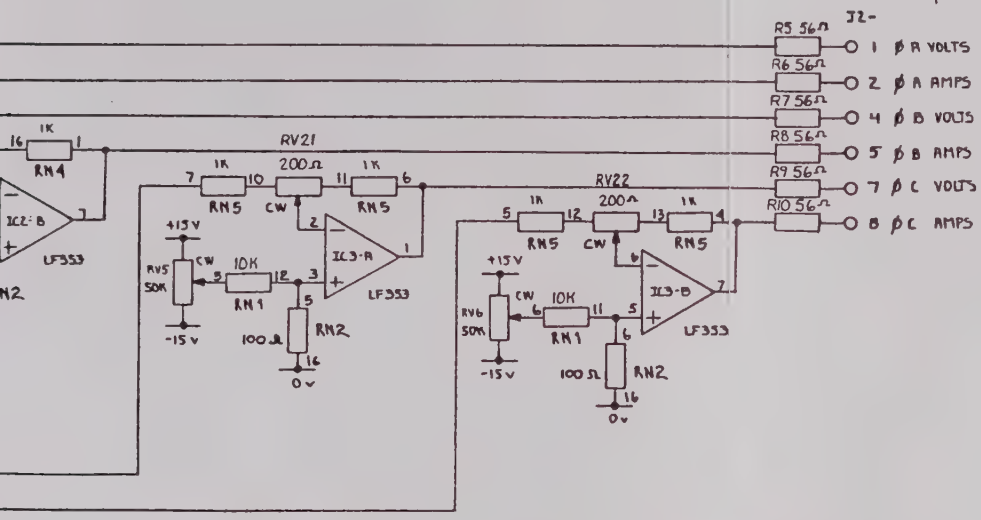
DRAWING NO. 2330-403

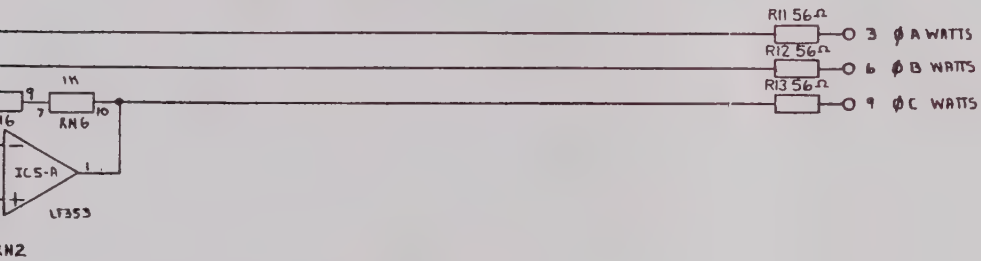
REV: B

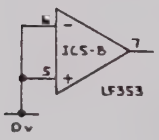
NOTES: (UNLESS OTHERWISE SPECIFIED)

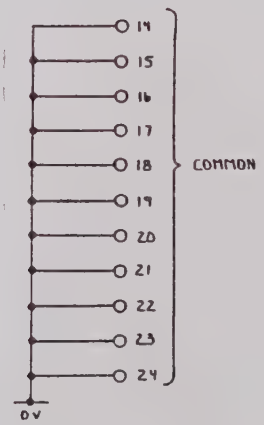


REVISIONS









POWER SUPPLY DISTRIBUTION		
IC	+15 V	-15V
1,2,3,4 5,6	8	4

FIRST USED	NOT USED	LAST USED
C1	—	C2
IC1	—	IC6
R1	—	R4
RN1	—	RN6
RV1	—	RV25

TOLERANCES
X = ± 30'
.XX = ± .03
.XXX = ± .010

BREAK ALL SHARP CORNERS AND EDGES. MACH. SURFACES 64

MATERIAL

FINISH

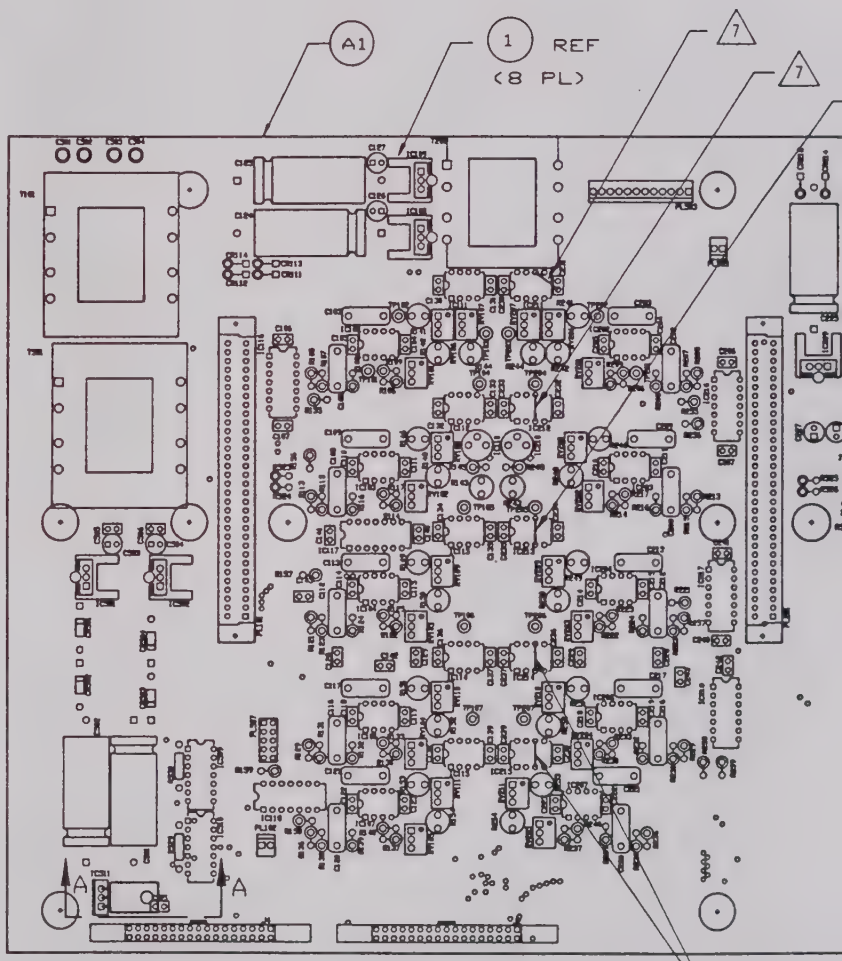
VALHALLA SCIENTIFIC
9955 MESA RIM RD. SAN DIEGO, CA. 92121

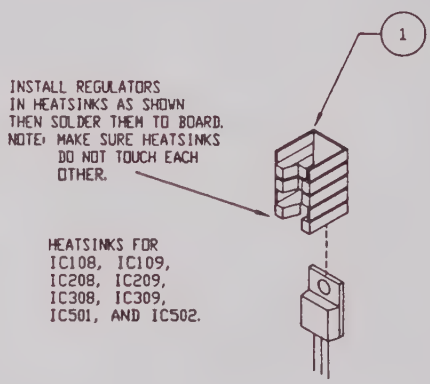
SCHEMATIC - OPTION .10X

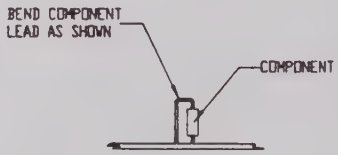
SCALE	CODE IDENT	SIZE	DRAWING NO	REV
SHEET 1 OF 1	53504	D	2330-076	B

NOTES: Unless Otherwise Specified

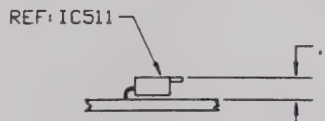
1. SEE SEPARATE PARTS LIST.
2. SOLDER HEATSINK TO P.C.B.
3. THESE WIRES ARE TO BE TWISTED APPROXIMATELY 1 TO 2 TWISTS PER INCH.
4. INSTALL CRIMP CONTACTS AS PER MANUFACTURERS RECOMMENDED PROCEDURE, USING MANUFACTURERS RECOMMENDED TOOLS.
5. MARK CONNECTOR WITH REFERENCE DESIGNATOR AS SHOWN USING A PERMANENT MARKER (COLOR: BLACK) FOR MARKING NYLON (PANDUIT PFX-0).
6. BEND IC511 OVER AS SHOWN. INSTALL WITHOUT HEATSINK.
7. INSTALL BUS WIRE ITEM (18).




1
INSTALL REGULATORS IN HEATSINKS AS SHOWN THEN SOLDER THEM TO BOARD.
NOTE: MAKE SURE HEATSINKS DO NOT TOUCH EACH OTHER.
HEATSINKS FOR IC108, IC109, IC208, IC209, IC308, IC309, IC501, AND IC502.



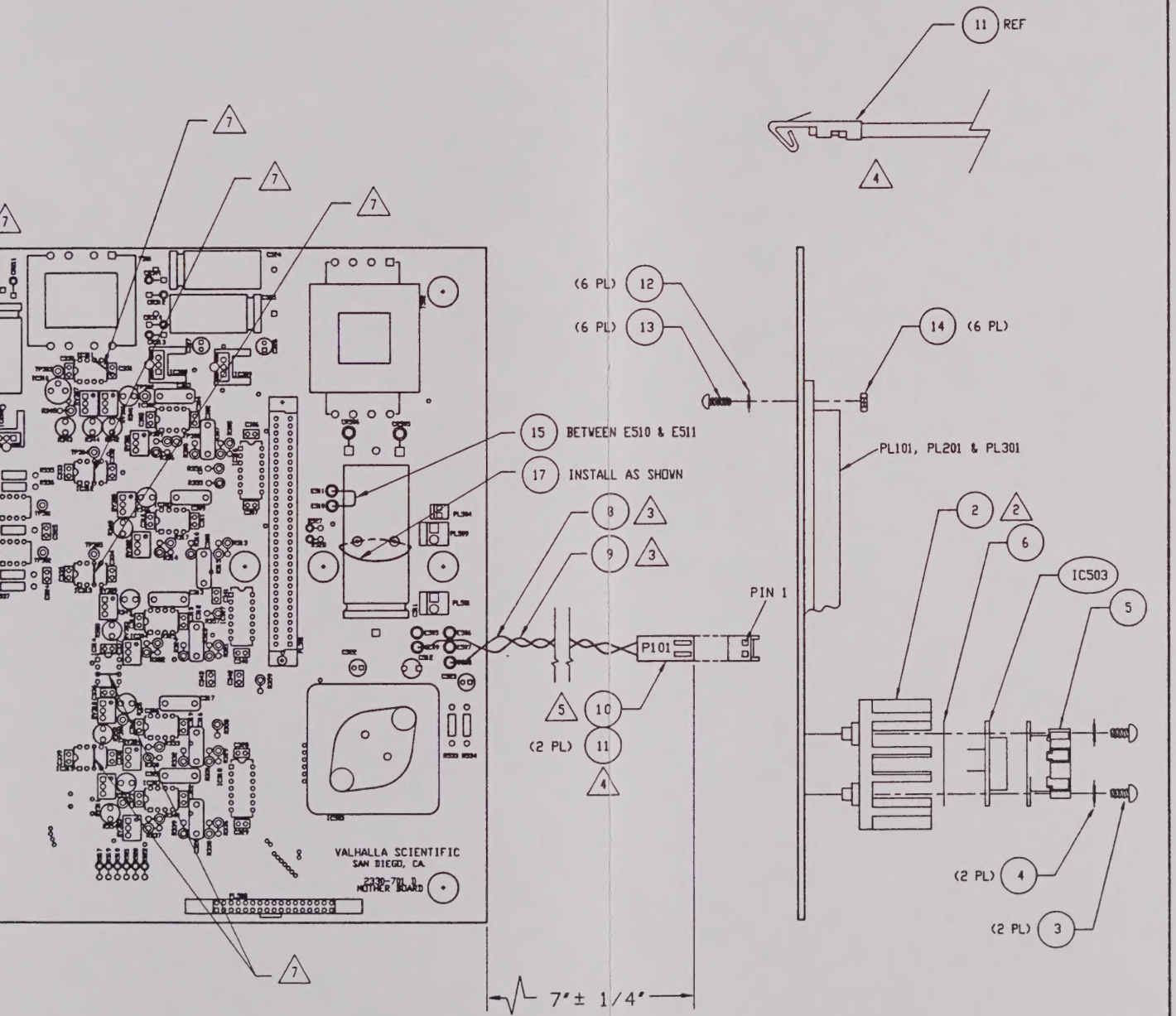
STAND UP COMPONENT DETAIL

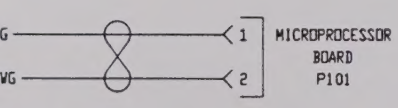


VIEW A-A 6

WIRING DIA

REVISIONS				
ECO#	LTR	DESCRIPTION OF CHANGE	DATE	APPROVED





TOLERANCES: X = ± 30' .XX = ± .02 .XXX = ± .005	FINISH:	MATERIAL:
DEBURR AND BREAK ALL SHARP EDGES AND CORNERS		
MACHINED SURFACES ARE TO HAVE A FINISH OF:	SCALE: 1 : 1	STOCK NO. 30-00159

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VALHALLA SCIENTIFIC
9955 MESA RIM RD. SAN DIEGO, CA 92121

TITLE	DRAWING NO.	REV.
ASSEMBLY - MAIN MOTHER BOARD, SINGLE CHANNEL	2330-608	L
SHEET 1 OF 1		

55505